A HIGH SCHOOL COURSE IN WOOD PATTERN MAKING

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PREFACE

This book is the outgrowth of seven years of teaching experience in both Trade and High Schools. The author submits the book on the ground that we can all benefit by the experience of others. Works on Pattern Making are not as numerous as the importance of the subject warrants.

The various articles in this book follow each other in what seems to the author to be the natural sequence. To begin the subject the teacher lectures on The Metal Trades (Chapters I and II), and the manufacture of iron products, so that the pupil can learn exactly what part pattern making plays in the commercial world. Then the wood working exercise in Chapter III should be started. Before beginning it, however the pupils, as a class, should be made to remove the plane bit and sharpen it and learn to replace it correctly. Pupils dislike to take a plane apart until the teacher proves to them that it is a simple operation.

While the pupil is working on the exercise, certain periods should be devoted to lectures and recitations on Moulding and Pattern Making, (Chapters IV and V,) so that these chapters are covered by the time the exercise is finished. Then the student will understand and can begin making the simple patterns in Chapter VI. If

lathes are scarce in the shop some pupils may be put at turning immediately after the first pattern. These pupils can then go back to the bench while others are turning. From parted patterns, to the end, the time spent on the bench preparing the pattern for the lathe, making the core box and finishing, exceeds the time spent at the lathe and a student need never be idle while waiting a chance to get on a lathe. Each student must have a bench.

Each individual kit of tools should be as small as possible. Large kits are difficult to keep track of. Each boy needs only: bevel, square, back saw, gage, scribe, dividers, rule, dust brush, jack plane, block plane, ½" chisel, 1" chisel, ¾" inside gouge, and ¾" outside gouge. Sharpening outfits must be as convenient as possible. If possible supply each bench with an oilstone.

Other tools are necessary but as they are not frequently used, a few of each may be kept in a convenient wall cabinet. There should be at least one-third as many lathes as there are pupils in the shop at one time and as many face plates as there are pupils taking the course. A band saw is indispensable.

Experience gained while a student at the Williamson School of Mechanical Trades enabled the author to arrange the course and his ten years experience as a pattern maker in large commercial shops enabled him to present actual shop methods.

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CHAPTER I.

THE METAL TRADES

As you walk along the streets of a city and observe the ornamental lamp posts, the U. S. mail boxes, or the fire plugs, or, as you hear the bell or whistle of a locomotive or the chug-chug of a gas or steam engine, has it not at some time excited in you a curiosity to know the processes by which such things come into being? Did it ever occur to you that the motor in your father's automobile, the parts of your mother's sewing machine, the hardware in your home, the plumbing fixtures in your bath room, or the pipe fittings and steam radiators which help make you comfortable, or even the artistic bronze statues which help beautify your parks, might be produced by processes which would prove to be a great deal more interesting to you than anything into which you have yet inquired? It is the purpose of these pages to get you interested in this art; the art of manufacturing metal objects, such as those mentioned above, and countless others.

To begin at the beginning, let us follow the manufacture of some new machine.

Your History has taught you that some clever men such as Watt, Whitney, and Fulton, first perfected certain new commodities. which were

of great benefit to mankind. You call them *inventors*. In those days inventions were produced only after long and tedious experiments with moving models. Nowadays when an inventor conceives a new machine, he sets it down on paper. He figures out its moving parts and their required strength, etc., often without attempting to make a working model. The result is a "drawing." With this drawing he tells others what has been in his mind. Drawing is the universal language of the engineer.

The inventor may not have an engineering education. In that case, he is obliged to employ an engineer to design his machine. After the *designer* has proportioned the parts, the *draftsman* draws the details accurately to scale and then a tracing and blue prints are made.

The blue prints are sent to a *pattern maker*, who reads them and fixes in his mind the idea that the designer intends to convey. He then proceeds to fashion certain forms in wood somewhat resembling the parts of the new machine. These forms are called *patterns*.

The patterns are then sent to the *foundry* where a workman called the *moulder* buries them in a special kind of sand and packs the sand hard around them. Then by ingenious methods, which have been anticipated by the pattern maker, he withdraws the pattern from the sand, leaving the full impression of the pattern in the sand. This impression is called the *mould*.

While the moulder is preparing the mould, the *foundryman* is firing up his *cupola* in which he melts bars of pig iron and quantities of scrap iron. When the iron is brought to a molten state, he rams a clay plug out of a tap hole near the bottom of the cupola, letting the molten metal flow down through a trough into a clay lined ladle in which it is carried to be emptied into the mould.

When the metal has cooled and is dug out of the sand, it is found to have the shape that was planned for it by the pattern maker and is called a *casting*.

To free the casting from the particles of sand which adhere to it, it is sent to the cleaning department, where it is tumbled around in a large revolving cylinder called a *tumbling barrel* or it is subjected to other treatment. The cleaned casting now goes to the *machine shop*.

These castings are somewhat rough; so in order that the parts of the machine we are building can run smoothly together, we must *finish* them off smooth on the surfaces which come into contact with each other. To that end, the machine shop is equipped with drill presses and boring mills for boring holes, lathes for turning cylindrical pieces, planers and shapers for making flat surfaces so that two pieces may be made to slide smoothly on one another or fit snugly together, milling machines, and other machines whose variety and functions are too numerous to mention.

After the castings have been finished, they are

sent to the assembling or erecting shop, where they are all carefully fitted together to make the complete machine.

Cast iron is brittle, and when made into slender shapes, is in danger of being broken if subjected to a shock. It is desirable to make such parts from a tougher material; therefore, *wrought iron* is used. Wrought iron cannot be melted in the cupola and poured into the mould. It is made red hot and hammered into the reuired shape. This work is done in the *forge shop*.

The student should know the above departments in their proper sequence and the function of each.

Departments Constituting a Machinery Manufacturing Plant and Their Functions

1. Drafting room: where the machine is planned and drawings made.

2. Pattern shop; where the forms for use in making the moulds for the parts are made.

3. Foundry; where the moulds and castings are made.

4. Forge shop; where the wrought iron parts are hammered out.

5. Machine shop; where the castings are finished.

6. Assembling shop; where the machine is fitted together.

Compare this with a modern technical high

school and you find that the high school is often a complete machinery manufacturing plant.

In a commercial shop the apprentice to any one of the above trades learns only his own trade. Think of the tremendous advantage you have over him since you will get a knowledge of all.

CHAPTER II.

BENEFITS OF SHOP COURSES

You may wish to finish your education at an engineering college. Then you must know the trades, for they are the very foundation of engineering.

You may wish to be a draftsman. You will then be required to make drawings of objects that are to be made by the processes involved in these trades. Your knowledge of these processes will serve you, in that you can design the objects so that it will be possible to make them by these processes. You will be more valuable to your employer than the office trained draftsman.

You may live in a community where the manufacture of iron products is the chief industry and there is a great field for mechanics. It would be natural for you, under these circumstances, to wish to learn one of the trades and you would be apt to think the others of no importance to you. As a matter of fact, a knowledge of the other trades would make you a broader and more efficient mechanic in your own line and you would rise above the average.

In no trade, however, is a knowledge of the others as essential as in the trade of pattern making.

The pattern maker must understand mechanical drawing as well as the draftsman himself under-

stands it; for he must not only read the drawing, but actually lay it out full size, no matter how large, before beginning the pattern. Every pattern shop possesses a stack of large and small drawing boards one of which is selected by the pattern maker who places it on a pair of horses, planes off the old drawing and proceeds to lay down a full size drawing of his new job accurately, scratching the lines on the board with a sharp scribe or knife.

It is obvious that the pattern maker must know moulding; since he must anticipate the needs of the moulder and so arrange the parts of the pattern that the moulder can draw the pattern out of the sand without breaking down any part of the mould. He must understand enough about machine shop practice to be able to act on his own account in such matters, as adding metal here or there for the machinist to plane or turn off in order to get a smooth surface on the casting. It often happens that he must decide where to put certain lugs or projections on the pattern, which do not appear on the drawing, but which are used by the machinist in chucking or centering the work in the machine.

In addition to this knowledge, the pattern maker must be highly skilful with the wood working tools in order to produce patterns which are smooth and clean cut. The ability to operate machine tools or wood working machinery is necessary. A surprising variety of work can be done on such machines by one who will take the

trouble to learn how. An illustration of what can be done on the circular saw can be found in the Oliver Catalog. Students in elementary pattern work will, however, have little except plain work on these machines.

Above all, the pattern maker must possess resourcefulness and be willing to use it continually. No mentally lazy person can become an efficient pattern maker. Any number of castings can be produced by the use of a single pattern; therefore, the pattern maker seldom has two jobs alike. Each new job calls for original thinking, planning and scheming. This thinking covers the whole range of the metal trades.

While the pattern maker works in wood, he has little in common with the carpenter and cabinet maker. His thoughts are mostly on metal. Therefore pattern making is classed among the metal trades.

From the foregoing it will be seen that in order to complete a course in pattern making hard work is requiied. Your teacher has a right to expect it from you. He has a right to suppose that you want this kind of work or you would not attend a manual training school. If you lean toward business or a profession you should have attended a commercial or academic school. But the author wishes to state that one who has no intention of following a mechanical pursuit, will find that the knowledge gained in this work will give him greater satisfaction, in after life, than many other things he has learned at school.

CHAPTER III

WOODWORKING.

Exercise I. (See Drawing, Fig. 8.)

Most pupils who take a course in pattern making have had a course in woodworking or cabinet making in the lower schools, therefore, it is not necessary to begin at the beginning. Many bad habits in the use of tools are formed by pupils, however; so this exercise, while it has nothing to do with pattern making, will serve as a review for the student and an opportunity for the teacher to correct bad habits before the more serious business of pattern making is taken up. As will be found later, the pattern maker's thoughts and reasoning are mostly in metal; therefore the student should be so familiar with wood work before he begins on patterns, that the wood working will not give him much concern. Considering then that the student has handled tools before and knows something about them, we will call attention only to the common mistakes found in all school shops.

The Plane The first tool that we use is the iron *jack plane.* Since the rough stock from which we make this exercise is only about 12½″ long we shall use the jack plane for smoothing and for truing the surfaces. If we had to plane very long pieces we should use a *fore plane;* but since none of our work is very long, the individual kits need not contain a fore plane. A pattern maker has not much use for a *smooth plane;* because it is seldom that he wishes simply to smooth a piece without truing it.

The best thing to do first, is to remove the bit from the plane, examine the parts, see how they work, and learn to put the bit back in place and lock the cap. Do this enough times so that you lose all fear of doing it and will not hesitate to do it, in the future, when the bit needs sharpening. Under the direction of the teacher learn to do it gracefully. This can best be accomplished by holding the plane with the bottom flat in the left hand and drawing the cap-cam up with the right. Do not let it snap as it may break off. To avoid a common mistake in replacing the bit, hold the plane on a level with the eye and see that the bit lies flat upon the frog. In order for the bit to lie flat, the little finger which forms one end of the "Y" adjustment, must penetrate the square hole in the plane-iron cap and the little disc on the lateral lever must engage the slot in the plane-iron. If you are careful about this, the cap-cam will go down easily.

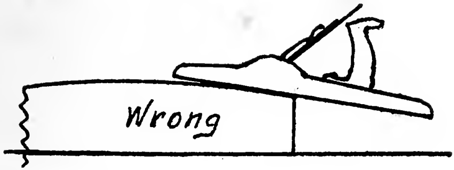


Fig. 1

In using the plane, most boys allow the rear of the plane to droop downward before the shaving begins (Fig. 1), and when the plane has gone nearly the full length of the piece, and the knob is just passing the far end, they allow the front end to droop. This procedure will cause a hump or a hill to be planed on your piece. You can never plane a piece true, until you have learned always to keep the bottom of your plane parallel with your piece as it lies flat upon the bench (Fig. 2).

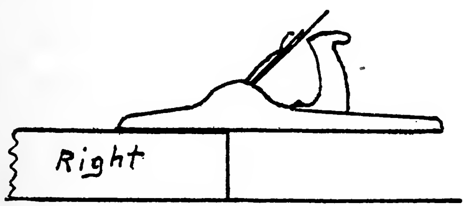


Fig. 2

Do not put the piece in the vise. If you push your plane straight to the bench-stop the piece will not dance around. The objection to putting

the piece in the vise is that too much time is lost opening and closing the vise to test the piece. You cannot afford to lose time in this course. Modern times demand *efficiency* from the workers; so we may as well begin, right now, to omit unnecessary motions.

Before planing, always run your finger lightly over the corners of your bit. If one corner projects farther than the other, change it by shifting the lateral lever. Never take a deep bite.

Sharpening the Bit The most disliked and at the same time the most necessary operation in wood working is sharpening the tools. Too much stress cannot be laid on the importance of keeping the edge of the tools keen. Every boy should be provided with an oilstone which is kept perfectly flat. In whetting a tool on an oil stone, try to maintain the bevel which is ground on the tool, raising the handle only enough to cause the edge to grind on the stone. Notice that one side of a paring tool is always *flat*. Keep this side *flat* on the stone and NEVER raise the handle or you will ruin the effectiveness of the tool. (Fig. 3.)

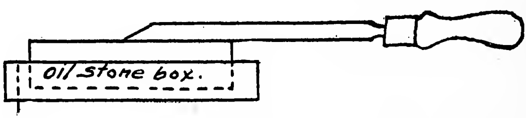


Fig. 3

One lesson from the teacher, if he gives you personal attention, will prove that in a very few minutes, you can sharpen a tool, so that you could shave yourself with it; and this accomplishment will make you so happy that you will never again try to work with a dull tool.

Try-Square The next tool we use is a try-square. It consists of a *blade* and a *beam*. Always hold the square loosely in the right hand, grasping the beam at its mid point (Fig. 4), and, when squaring an edge or end, see that you press the beam firmly against the *Face Side* or *Face Edge*, allowing the blade to touch lightly the surface being tested.

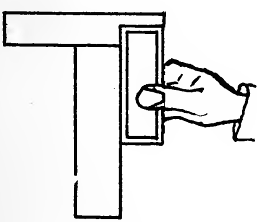
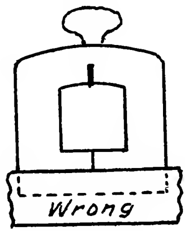


Fig. 4

Fig. 5



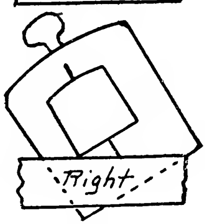


Fig. 6

Gage The *gage* is an instrument that boys have difficulty in using. The great mistake is that they dig the *spur* into the wood so deeply

that the head will not slide freely along the *Face Side* or *Face Edge.* (Fig. 5). To avoid this, tilt the head over until the corner of the beam bears on the edge that you are marking and the pressure rides mostly on this corner, leaving only enough pressure on the spur to make a fine light hair line. (Fig. 6.)

Scribe No pencil line is sufficiently accurate for this course and its use cannot be permitted. All laying off must be done with a scribe or knife, which must be sharp. The line must be deep and clean cut. It must be a hair line and we must work so accurately that by the expression "Working to a line" we mean splitting this hair line. These lines not only serve as a guide but also when planing off an end, prevent the little slivers from breaking out beyond the line and make a clean cut, square corner. Lay out everything with a knife accurately; then split the line and your work will be done correctly in one-fourth the time taken by the man who is too lazy to lay out the work, but takes off a shaving and then measures or tries the square and then takes another shaving, etc. This "cut and try" method does not make for efficiency.

Back Saw The chief difficulty in using this tool is to get the cut started. It is a mistake to put the teeth flat on the piece and try to start the kerf parallel with the line. You must start the kerf on the far corner. Hold the piece tightly

against the bench hook with the left hand and then, without exerting pressure on the saw, draw the teeth across the corner at an angle to the surfaces, gradually lowering the handle as the kerf progresses, until the kerf is parallel to the line. (Fig. 7.) In these exercises you must never let the saw touch the line, but go very close to the line leaving only enough so that you can pare off a slight shaving with a plane or chisel.

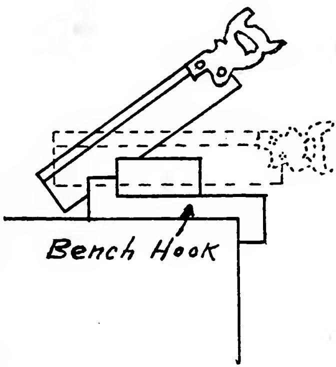


Fig. 7

Block Plane This little plane is used for planing end grain on small blocks. Right here you should learn that, in order to cut wood smoothly, the tool must be given a lateral or sidewise movement, as well as a forward movement, otherwise you would *squeeze* the wood off, not *cut* it. To make this plain, imagine yourself cutting fresh bread. In this case you draw the knife

toward you as well as press it down. This *Drawing Cut* will be insisted upon in all block plane and chisel work, where the wood fibers must be severed. This is not necessary in cutting "with the grain." The block plane should be held almost wholly within the right hand and the bit allowed to pass across the work at 45° to the edges and be drawn across the grain at the same time that it is pushed forward. The result should be a polished surface.

Bevel This is like a square with an adjustable blade, so that, with it we may draw lines at other angles than 90°.

Chisel It is foolhardy to attempt to use any but the keenest edged chisel on this work. You now know how to sharpen a plane bit. A chisel is much easier to sharpen. The same caution for whetting applies here: "Keep the *back* flat."

Two other necessary precautions are: "Use the drawing cut," and "Keep the brake on." By the latter is meant that you must keep your left hand rigidly braced against the job and allow the tool to slide between the thumb and forefinger, being ready at any time that the tool threatens to slip, to clamp the fingers together tightly and arrest the tool, before it slips out and splits away some of the wood that you didn't intend it should touch.

In modern industrial management it has been

found of advantage to issue *instruction cards* to mechanics, outlining in their proper sequence the operations which shall be performed on each piece of work. If this is an advantage to an experienced mechanic certainly it is of far more help to the inexperienced one. Below is an outline of operations for making the first exercise.

INSTRUCTION CARD

Exercise in Working to Scribe and Gage Lines with Saw and Chisel

1. Saw out a piece of rough white pine about $1'' \times 2\frac{1}{4}'' \times 12\frac{1}{2}''$.
2. True the Face Side with a jack plane and mark it. (To test the first side; hold it up to the light parallel with the line of sight. If one corner appears high, plane it off and then test all over with the back of the square blade.)
3. True the Face Edge and mark it. (This must be squared with the face side. Hold the square as explained under "Square.")
4. Plane the second side parallel to the Face Side. (Use gage lines to lay off the thickness.)
5. Lay off one end with knife and square. Saw off very near to line and plane to line with a block plane. (Always clamp beam of square tightly to either *Face Side* or *Face Edge*, no other. Line must run all around the piece.)

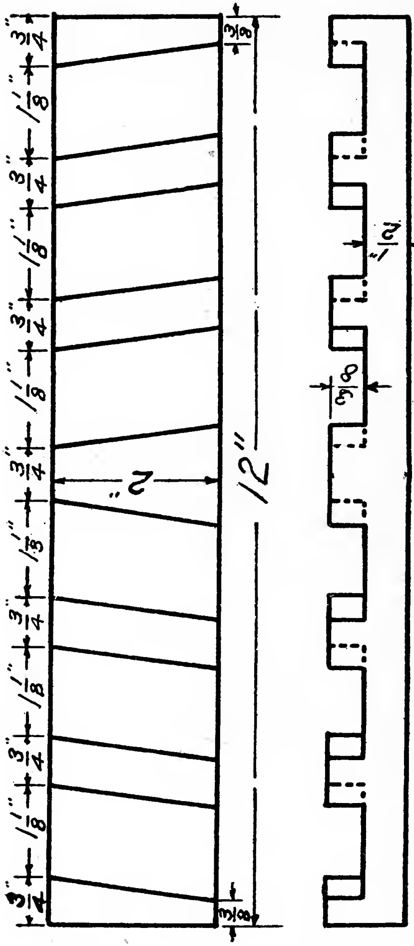


Fig. 8. Exercise in Working to Scribe and Gauge Lines with Saw and Chisel

6. Lay off the length and plane the other end.
7. Plane off the second edge parallel to the Face Edge. (Using gage lines to get the width.)
8. Measure along one edge and point off location of the lines for the gains. (Hold rule firmly against job, the divisions on the rule meeting the corner you wish to mark. Do not move rule each time you make a mark.)
9. Draw the outlines of the gains. (Use the following tools: bevel, knife, square, and gage.)
10. Saw just inside the knife lines in each gain, leaving very little to chisel off.
11. Chisel out the bottoms of the gains with a 1-inch chisel. (Use the drawing cut.)
12. Chisel off the sides of the gains. (Use the drawing cut.)
13. Stamp your name and section on end of piece with steel letters. (Stamp name on *end grain* on every exercise.)

While the student is spending his shop periods making this exercise he should be spending his recitation periods acquiring a theoretic knowledge of the metal trades so that he can grasp the meaning of *pattern making* before he attempts to make his patterns.

CHAPTER IV.

MOULDING

Moulding is of such importance to the student of pattern making that it is well to give him an insight into it, at the outset. If there is no foundry connected with the school, at least one moulding bench should be equipped and maintained for demonstration purposes.

The purpose of these pages on moulding is not to give a complete course in moulding, but to give enough data so that by following the directions here given enough moulding can be done to demonstrate and make clear in the mind of the student just what happens to a pattern after it leaves the pattern shop; to impress him with the importance of designing his pattern to suit the needs of the moulder.

A *mould* in connection with the foundry business, is a shaped opening in the sand into which hot metal is poured in order to produce a casting. There are three classes of moulding:

1. Loam moulding.
2. Dry sand moulding.
3. Green sand moulding.

Loam moulds are used for casting very heavy, plain pieces; for example, a large, cylindrical drum

for hoisting. The loam is a mixture of old moulding sand and chopped straw, which, when properly dampened, makes a plaster-like mass. This is plastered on a circular brickwork support, built to the approximate diameter, upon a large iron plate. A *sweep* is revolved on a spindle erected at the center. This will sweep a smooth round layer of loam on the inside of the circular brickwork. The surface is now dried and the whole thing lowered into a pit and packed around with sand to strengthen it, so that the weight of the metal will not burst out the side. The smooth surface will form the face of the drum. The hub and arms may be made in dry sand forms. It will be noticed that no large pattern is used in making this mould; but the pattern maker must be familiar with it, because he will be called upon to make the sweeps, or skeleton patterns, which may be required.

Dry sand moulds are used for casting heavy work having considerable detail. A good example of this is a large steam engine cylinder, with its flanges, steam chest, exhaust outlet, etc. This mould is made in the same way as the green sand mould, which will be described in detail later; but is thoroughly dried in an oven before pouring. The hot metal flowing in, causes less steam than in a green sand mould, and the hard caked mould offers more resistance to the heavy metal.

Green sand moulds, by far the most frequently used, are used for making medium and small cast-

ings. The material used for making a mould is called *moulding sand* and is found in nature. It is found at various places in the United States and brings a good price. It is a combination of sand and clay. The sand component serves as the heat resisting element and its open grain keeps the mould porous, so that the steam and gases may find their way to the vent holes. The clay component serves to bind the particles of sand together so that the mould may be made to retain its form. Obviously clay alone could not be used, as the heat of the metal would bake the clay around the casting, like a brick. The sand causes the dried matrix to crumble easily, so that the casting may be removed.

There are two branches of green sand moulding: bench moulding and floor moulding.

Moulds for machine parts, such as a lathe bed, lathe leg, bandsaw frame, etc., are made in large flasks on the floor. Small things, like water faucets, small pipe joints, etc., are moulded in small flasks, on a bench, for convenience in handling.

We shall confine our attention to bench moulding; as it will serve to illustrate the principles of moulding which the student of this course must know.

Tools Used in Moulding

1. Flask: an open wooden or iron frame, in

two or more sections, into which the sand is packed to make the mould. (Fig. 9.)

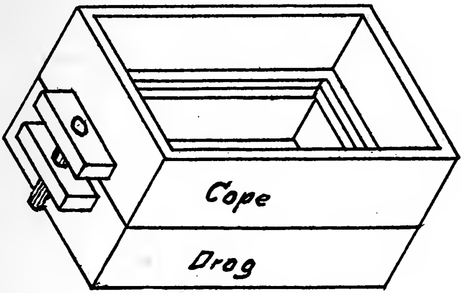


Fig. 9. Flask

2. Cope: the upper half of the flask when in position for moulding.

3. Drag: the lower half.

4. Cheek: the intermediate portion when the flask consists of more than two parts.

5. Mould board: a flat board on which the pattern and drag are placed for ramming up. (Fig. 17.)

6. Bottom board: similar to mould board, on which the flask rests after rolling over. (Fig. 18.)

7. Pattern: a near model or form by the use of which the mould is made.

8. Rammer: an instrument used for packing sand into the flask. (Fig. 10.)

9. Sprue pin: a cone shaped piece of wood which is rammed in the cope and which, when

withdrawn, leaves a hole for conducting the metal into the mould. (Fig. 11.)

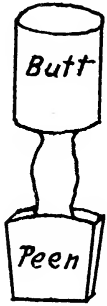


Fig. 10. Rammer

Fig. 11. Sprue Pin

10. Gate cutter: a bent piece of brass fitted with a handle, and used for cutting a channel leading from the bottom of the sprue hole to the mould.

11. Trowel: a flat, handled blade used for smoothing large surfaces.

12. Slicker: a double ended (leaf and spoon) instrument used for smoothing flat and rounded surfaces and for patching. (Fig. 12.)

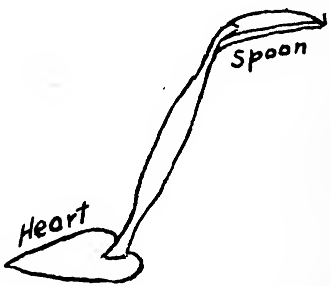


Fig. 12. Slicker

13. Corner slick: used for patching corners.

14. Vent wire: a handled rod for piercing holes through the sand to the imbedded pattern to allow the air, steam and gas to escape.

15. Draw screw: a threaded rod which is screwed into the imbedded pattern to act as a handle for pulling the pattern out of the sand.

16. Swab: used for dripping water around edge of pattern to strengthen sand.

Terms

1. Ramming up: packing sand in flask.

2. Sprue: opening through the cope left by sprue pin. (Fig. 14.)

3. Gate: channel connecting sprue and mould. (Fig. 14.)

4. Vents: openings provided for escape of gases, air and steam.

5. Gases: formed by combustion of organic matter in the sand and by chemical reactions in the cooling metal.

6. Rapping: gently tapping pattern to loosen it from surrounding sand.

7. Drawing: removing pattern from sand.

8. Pouring: filling mould with molten metal.

9. Shaking out: dumping sand and casting out of flask after metal is hardened.

Cores A hole through a casting or an internal cavity in a casting is made by using a core. A *core* is a body of sand projecting into,

or supported in the mould. The metal flowing into the mould will surround the core and after it cools the core sand can be cleaned out leaving an empty space. The core must have the same shape as the required cavity. This is accomplished by ramming core sand into a core box. A *core box* is made of wood, its interior carved out to the same shape and size as the required cavity in the casting. (Figs. 15 and 20.) The core box is often made in halves, held together with *dowel pins*. The halves can be separated and the core dumped out. Large core boxes are built up. (Fig. 86.) It is the pattern maker's duty to make the core box. It is considered part of his pattern.

Core sand is a combination of sharp sand and flour water, molasses water, or stale beer, the function of the last named being to bind the sand together so that it will hold its shape. The core is dumped from the core box upon an iron plate and placed in a *core oven* to bake. When baked, it is a hard mass that can be handled without fear of breaking. *Core making* is a separate trade.

The hard core can be placed in the proper positon in the mould. The pattern maker has anticipated this and has provided means for marking the resting place of the core. This he accomplished by making projections on the pattern (Fig. 13-3) the size and shape of which were determined by the size and shape of the hole

or cavity in the casting, at the point where the hole or cavity cuts through the casting. These projections are called core prints. Therefore, *core prints* are projections on the pattern which mark out in the mould the resting place of the core.

The core sand is easy to remove from the interior of a casting because the hot iron burns out the flour or molasses and destroys the bond, leaving the grains of sand free to flow from the cavity.

Cores must be provided with vent holes to carry off the gases which form around them.

Vertical cores are those which stand on end in the mould. (Fig. 14.) Their upper ends must be cone shaped and the cope core print is similarly cone shaped, so that, when the cope is lowered, the upper end of the core will be sure to enter the tapered hole formed by the *cope* print. This also serves to bring the core to a vertical position in case it had been leaning.

Horizontal cores rest on two or more supports, one at each end. (Fig. 18.)

Balanced cores have a free end projecting into the mould. In order to hold such a core in place the end which is supported is enlarged to be heavy enough to balance the free end. Such a core may also be held in position by chaplets.

All the cores above are *dry sand cores;* but there there is another kind called a *green sand core,* which is formed right in the hollow pattern and is

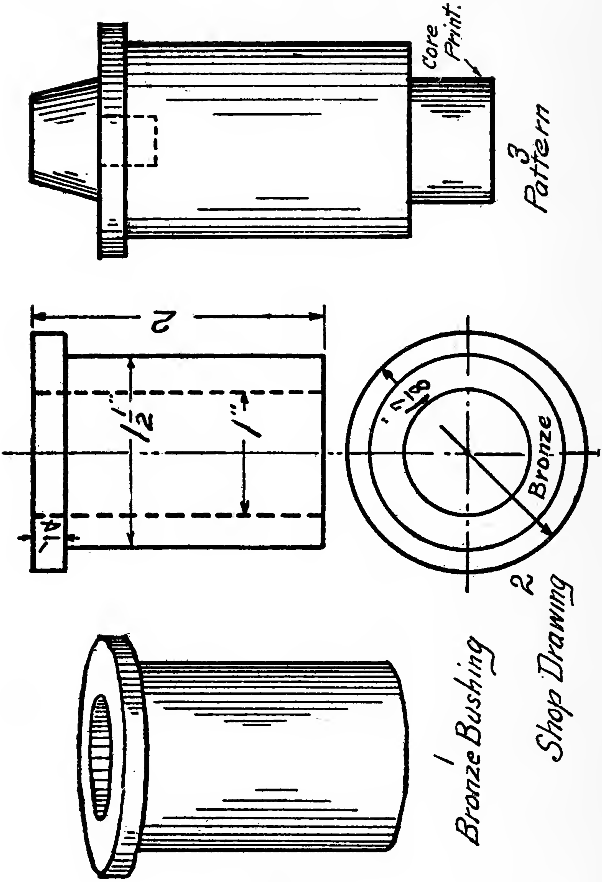

Core Print.
3 Pattern
2
1 1/2"
1"
1/4"
1 1/8"
Bronze
2 Shop Drawing
1 Bronze Bushing

Fig. 13

left standing when the pattern is withdrawn. This is spoken of as the pattern "leaving its own core."

Fig. 13 illustrates what has been given above.

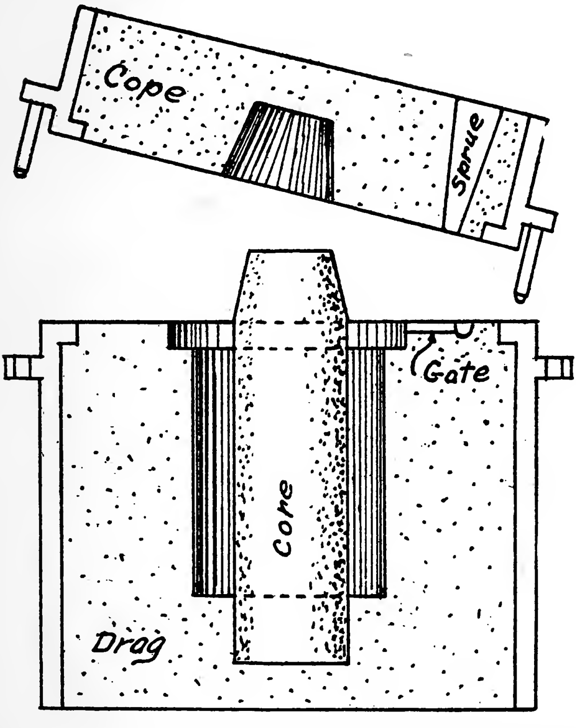


Fig. 14. Section View of Mould for Bushing, Ready to Close

Fig. 13-1 shows an ordinary bronze bushing. Fig. 13-2 shows a regulation shop drawing for

the bushing. In this case the pattern maker decides that the most convenient way to get the hole through the casting is to make use of a dry sand vertical core and to mould the pattern on end. Core prints are therefore provided to hold the core in place. Fig. 13-3 shows the pattern with its core prints. For convenience in ramming up this pattern, the cope, or tapered print, is not fastened to the pattern permanently, but is held in its proper place by a pin and can be easily removed.

Fig. 14 is a cross section view, through the center of the mould for the bushing. The flask can be seen filled with sand in which the pattern has been imbedded and withdrawn, leaving its impression in the sand. The core is seen standing on end, its lower end fitting snugly into the impression left by the drag print, and its upper end tapered to insure its entering the cope print.

Notice the sprue running through the cope. The metal is poured into the sprue from the moulder's ladle, and finds its way into the mould through the gate.

For heavy casting, the cope must be weighted or clamped down to prevent floating and a consequent leak between the flasks.

Fig. 15 shows one-half of the core box in which the core is made.

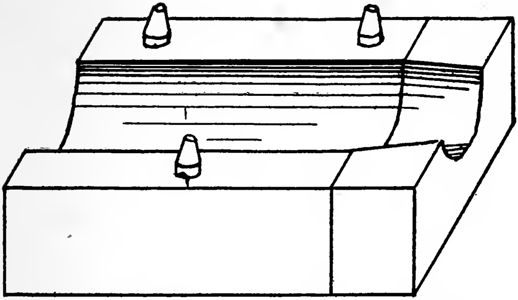


Fig. 15. Half of Core Box for Bushing

Shrinkage It has been found that molten cast iron (C. I.) while cooling shrinks in size, until it is just at the point of solidification, when there is a slight expansion and then a further contraction, until it reaches the temperature of the atmosphere.

This shrinkage occurs in all the dimensions of the casting and has been found to approximate ⅛″ shrinkage per foot of dimension. If one wished to cast a bar of iron one foot long he would be obliged to make his pattern 12⅛″ long. The metal would be poured into a 12⅛″ mould, but after all shrinkage had occurred the bar of cold metal would be 12″ long. If it were desired to have the same bar one inch thick it would be necessary to make the pattern 1″ plus 1/96″ thick because if the shrinkage is ⅛″ in 12″, in 1″ it would be $1/12 \times 1/8 = 1/96''$, and so on, for every dimension. From the foregoing, it would

appear as if much laborious calculation is necessary in pattern making. This is *not* the case, however, as the pattern maker provides himself with a

Shrinkage Rule

This rule looks like a *standard* two-foot rule; but if compared with a standard rule it will be found to be ¼″ longer or 24¼″ long. This length is divided into 24 equal spaces. Each space must, therefore, be 1 1/96 standard inches long. These are again subdivided into divisions corresponding to the eighths and sixteenths on a standard rule.

One has only to measure every dimension on his pattern with a shrinkage rule to give the necessary increase in size to overcome the loss caused by shrinkage.

Steel shrinks 3/16″ per foot; brass (Br.) 3/16″ per foot; and other metals have different shrinkages. The pattern maker must provide himself with a rule for each.

Draft In order to make it easier for the moulder to draw a pattern from the sand the pattern maker tapers the vertical sides of the pattern. This taper is called *draft*. The customary amount is ⅛″ per foot in height. Where the height is only an inch or two, the taper cannot be measured, therefore the nearest one can come to laying down a rule for it is to say that only a slight taper is necessary.

Parted Patterns A pattern of cylindrical shape is difficult to remove from the sand. Here again the pattern maker makes it easier for the moulder by making the pattern in halves, loosely held in their proper relation to each other by dowel pins. This is called a *parted* pattern. The half containing the *dowel pins* is called the *cope half* and is moulded in the cope flask. The half containing the *dowel pin holes* is moulded in the drag flask and is known as the *drag half* of the pattern. The pipe joint (Fig. 16)

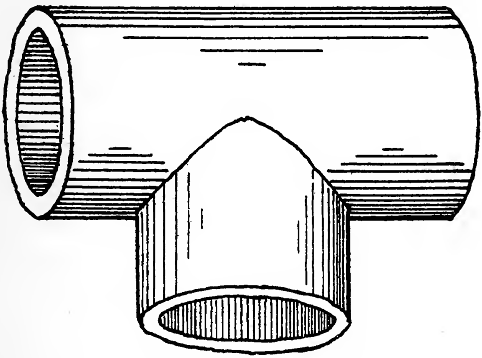


Fig. 16. Pipe Joint

spoken of in the following chapter requires a pattern of this class.

Most parted patterns are parted on their center line. However, patterns whose shape is not symmetrical must be parted on some other line de-

termined by the direction of the draft on either side of this line.

Though it is customary to part cylindrical patterns, it is often found expedient to make the pattern solid and allow the moulder to *cut* his *parting* with a trowel. That is, he imbeds the whole cylinder in the sand and then cuts the sand away, down to the center line, rams up the cope and allows the cope to lift off the impression of the upper half of the pattern. The pattern now has nothing to impede its withdrawal from the sand. This will readily be understood after the student has seen a demonstration in moulding.

Making a Mould for a Small Pipe Joint

The sequence of operations to be followed in making this mould follows:

1. Place the drag half of the flask, pin holes down, on the moulding board.
2. Place the drag half of the pattern, flat side down on the moulding board inside of the flask. (Fig. 17.)
3. Place the sieve on top of the flask, fill with facing sand, and shake until the pattern is completely covered. (This removes any lumps which would cause rough spots on the casting.)
4. Shovel common sand on top of this until the flask is heaped full.
5. Pack the sand hard with the rammer. (Use

the peen to get close to the edge and use the butt in the center.)

6. Strike the sand off level with the top of the flask, with a straight edge.
7. Make the vent holes.
8. Sprinkle a little loose sand over the top and rub down the bottom board to a good bearing.
9. Clasp both boards and flask together firmly and roll over.
10. Remove the moulding board.
11. Fit on the cope half of the flask.
12. Fit on the cope half of the pattern.
13. Sprinkle on parting sand.
14. Push the end of the sprue pin into the drag sand allowing the main body of the pin to extend upright through the cope.
15. Fill the cope flask full of sand, ram up and strike off.
16. Make vent holes.
17. Remove the sprue pin.
18. Place the moulding board on top of the cope.
19. Carefully lift the cope, turn over and put aside.
20. Drip water around the edge of the pattern with a sponge or swab.
21. Cut the gate from the sprue to the pattern.
22. Insert the draw screw, rap and draw both halves of the pattern.
23. Dress up any portion of the mould which may have been accidentally broken.
24. Place the core in position, its ends resting in the core print spaces. (Fig. 18.)

25. Close the mould.
26. Pour in the melted metal.
27. When sufficiently cooled, shake out.
28. When cold, chip off the gate, clean the sand off the outside and clean the core sand out of the inside.

We now have what is known as the *casting*. (Fig. 16.)

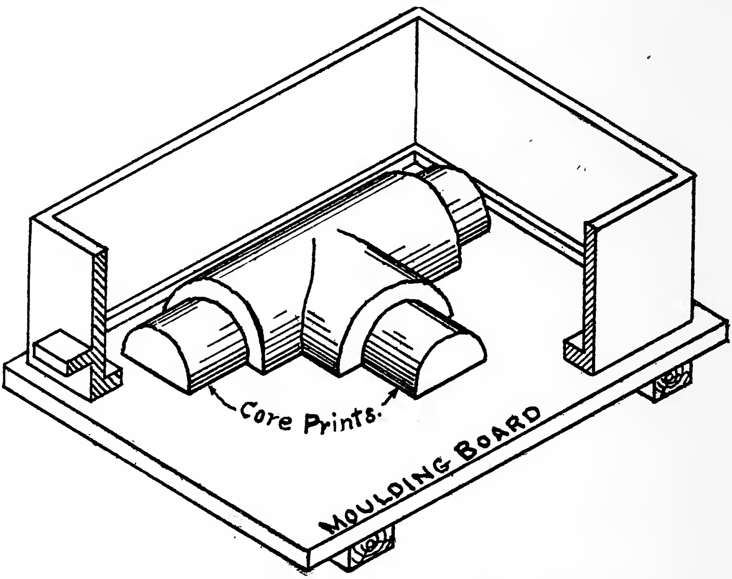


Fig. 17. Pipe Joint Pattern in Flask, Ready to Ram Up

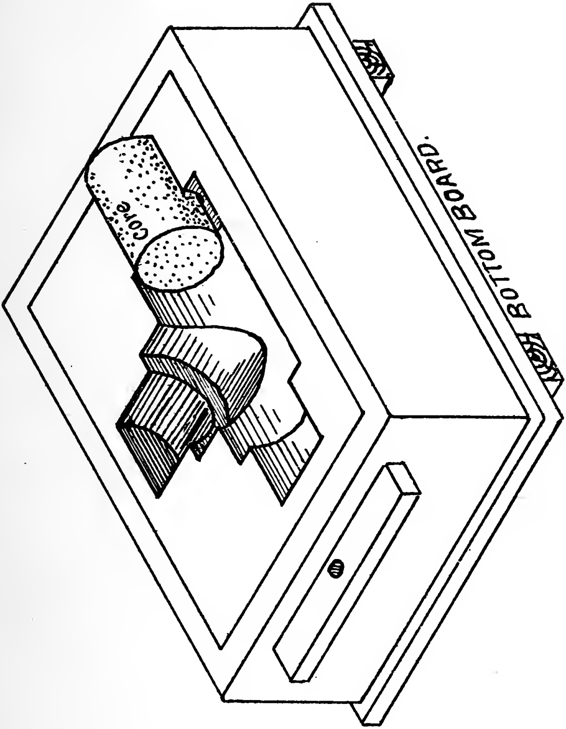


Fig. 18. Drag Half of Mould with Core in Position. Part of Core is Broken off and Removed in Order to Show the Interior of the Mould

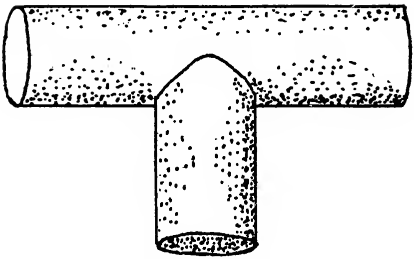


Fig. 19. Core for the Pipe Joint

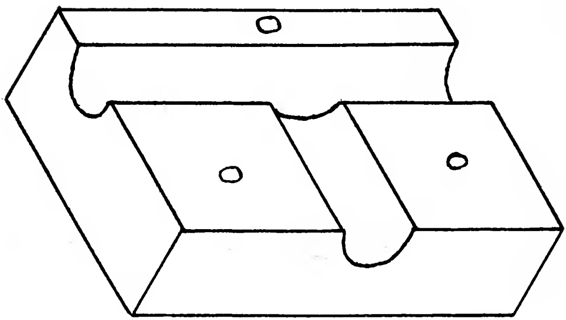


Fig. 20. Half of the Core Box for the Pipe Joint Core

CHAPTER V.

PATTERN MAKING

Pattern making is the art of making forms, or near models, by the use of which sand moulds are made.

An extended range of thought, skill, and experience is necessary for efficient pattern making. The pattern maker must possess a greater variety of talents than the mechanic of any other branch of the metal trades. Owing to the great field which it covers, a course in pattern making offers an unusual opportunity for mental development in addition to training the hand.

Lumber The material from which ordinary wood patterns are made is *white pine*. The best quality of white pine for the pattern maker's use, is known as Michigan white pine. It grows in Michigan and the adjoining northern states. It grows in immense trees, from one hundred to two hundred feet in height and two to four feet in diameter. It is soft, very light in weight, of almost a cream color, is durable, warps little as compared with other woods, can be easily worked with wood worker's tools and usually has a very straight grain. These properties make it very desirable for pattern making:

but owing to its growing scarcity it is becoming very expensive. Therefore, if you are given white pine from which to make your patterns, be very economical in its use. Be sure to learn the difference between white pine and the other soft woods usually found around a manual training shop, and use only white pine for your patterns, if you want them to retain their original shapes.

Patterns which are to stand extraordinary use, that is, which are to be used hundreds of times in the foundry, are made of hard woods, such as *mahogany, cherry* or *walnut,* all of which are easily worked, considering that they are hard woods.

Lumbering and sawmilling should be interesting to a student of this course and much interesting reading can be had on the subject. The *seasoning* of lumber is of such importance that we must give it some attention in these pages. By seasoning we mean "Drying out the sap."

When trees are felled they contain 50% by weight of moisture, due to sap which circulates through the tree. By a long period of drying in air, in a sheltered place (two years for a 1" board), this moisture can be reduced to 12 or 15%. As the wood loses its moisture, it becomes considerably smaller: in other words, it shrinks. Therefore, if we wish to make a wooden object which is expected to retain its original size and shape, we must be careful to use well seasoned lumber.

The moisture in a 1" board can be reduced to 5 or 6% in a few days in a *dry kiln* (a dry kiln is a

steam heated compartment heated to about 180°.), but when brought out of the kiln it absorbs moisture from the atmosphere until it contains the usual 12 to 15%. The amount which it contains *varies* with the moisture in the atmosphere. This explains why wood continually changes and why furniture often creaks, seemingly without cause.

Certain laws govern these changes and the pattern maker must familiarize himself with them. He must anticipate what changes will occur and build his pattern so as to minimize the ills. Thus *framing* up a wide flat pattern (Fig. 21) and *staving* up a large round pattern (Fig. 22) would be resorted to, in order to do away with a wide cross grain and its consequent shrinkage; and *open joints* would be resorted to, in order to distribute the shrinkage evenly; and *battens* (Fig. 23) would be used to hold a curling piece straight. In the

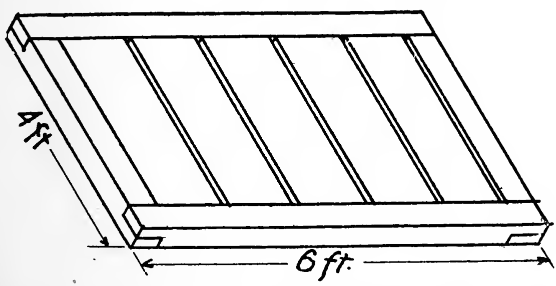


Fig. 21. Large Flat Pattern Framed Up. Open Joints Between Boards Distributes Shrinkage and Swelling Equally

latter case, as the battens form no part of the casting, the moulder fills them up. Instructions to the moulder *fill up* must be painted on the battens with black shellac.

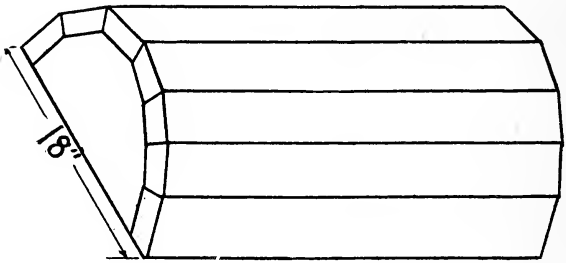


Fig. 22. Half of a Large Cylinder, Staved or Lagged Up.

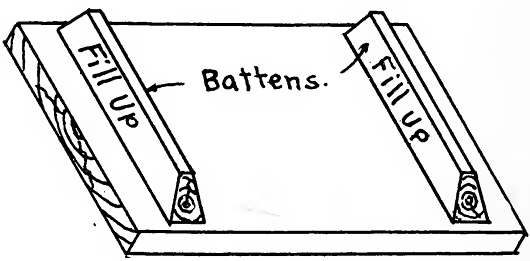


Fig. 23. Battens

If wood is allowed to lie flat on the bench in a warm room its upper surface will dry out and contract, causing an upward curl. (Fig. 24.)

If a board is allowed to lie flat on the bench in

a damp atmosphere, the exposed side will absorb moisture from the atmosphere and swell while the under side is protected and remains the same size, causing it to curl concave down. (Fig. 25.)

Fig. 24

Fig. 25

Fig. 26

The old wood at the heart of the tree will dry out less quickly than the newer open grain sap wood near the bark; so a board has a tendency to curl away from the heart. (Fig. 26.) For this reason, a pattern maker, in making a job which is very particular, would select a board which is sawed radially with the log, or a *quarter sawed* board. To determine a quarter sawed board, one

must inspect the annual rings on the end of the board. (Fig. 27.)

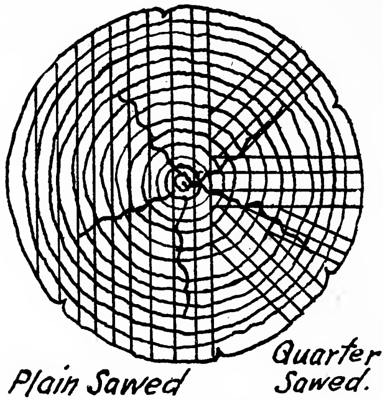


Fig. 27

The porous, end grain of a board dries and contracts more quickly than the solid mass of wood, causing a strain and finally a split. This is called a *check* and may be prevented by shellacing the end, immediately after it is trimmed off.

The unit of board measure is the board foot.

Drawings *Drawings* are representations of the finished iron object. They are made for the machine shop, to guide the machinist in cutting, boring, planing and fitting, so as to produce an object embodying the general requirements. No drawing of the pattern is furnished for the pattern maker. The pattern maker gets what information he can from the machine shop

drawing and then makes, from his imagination, some form in wood, which the workman following him can use to produce the required object. The pattern often does not look like the desired object, but bears only a general resemblance to it. Drawings are seldom made full size. The pattern maker lays down a full size drawing of the pattern on a board, making the lines with a knife instead of pencil.

Drawings are seldom correct. Dimensions are often changed on the blue-print, without making a corresponding change in the lines; therefore keep to the given dimensions and scale the drawing only when the draftsman has omitted the dimensions. The blame for a mistake then rests upon the draftsman.

The style of drawing used in shop drawing, is called *orthographic projection.* Practically all high schools that have a course in pattern making, also have a course in mechanical drawing; therefore instruction in drawing will be left to the Mechanical Drawing Department.

Allowances in Pattern Making There are three additions not called for on the drawing, which the pattern maker must put upon the pattern; namely, *finish, shrinkage,* and *draft.*

Finish is an addition of 1/8" of extra metal on all surfaces which are to be machined smooth in the machine shop. (Fig. 29.) Surfaces which fit

together, slide on one another, or revolve one in the other, are treated in this manner. Such surfaces are indicated by a little "f" on the drawing. The "f" crosses the line representing the surface to be smoothed. (Fig. 28.)

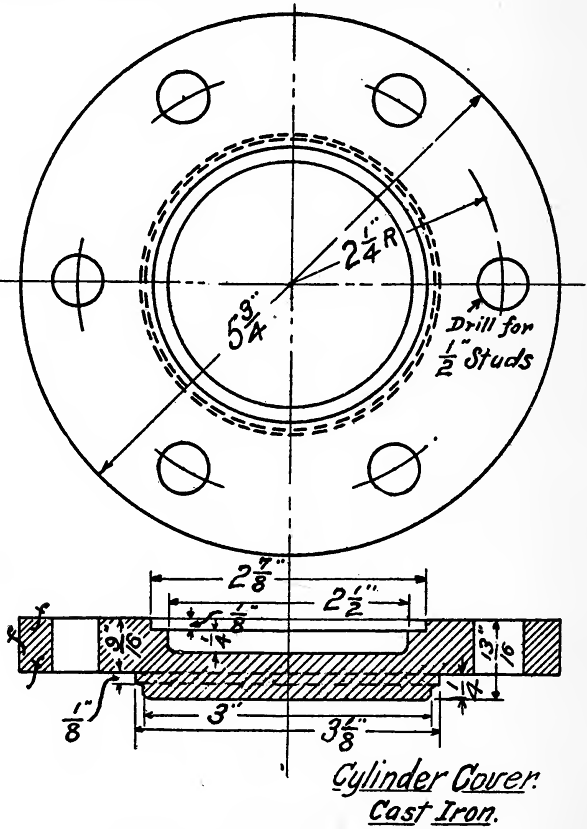


Fig. 28. Shop Drawing of Cylinder Cover

Shrinkage is an addition of 1/8" per foot to overcome the loss caused by the shrinkage of the metal in cooling. This shrinkage of metal is explained under Moulding.

Draft is a slight taper (1/8" per foot) on the vertical sides of patterns to facilitate the withdrawal from the sand. (Fig. 29.)

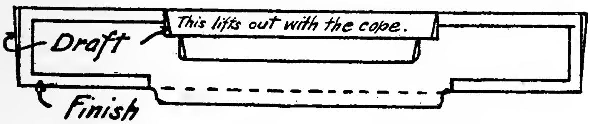


Fig. 29. Drawing of Pattern for Cylinder Cover Showing Allowances. Measured with the Shrinkage Rule

The pattern maker's drawing must show that these allowances have been added. A sample shop drawing and a pattern drawing are given in Figs. 28 and 29. Students must follow this form.

Fig. 28 is a sample of the kind of drawing usually furnished to the pattern maker. It is a picture of the finished cast iron object.

Fig. 29 is a sample of drawing made by the pattern maker from information given by the shop drawing *plus* the allowances which he knows he must add. This is a picture of the *Pattern*. Note the difference. Frequently as in this case, a *cross-section* only is required. The pattern maker omits the plan view and dimensions, but makes the drawing full size.

CHAPTER VI

BENCH WORK

Pattern No. 1, Introducing Finish, Shrinkage and Draft

The drawing opposite represents a machine shop exercise in chipping and filing. In order that the machine shop student may produce this object, he must be supplied with a block of cast iron of the approximate shape. The foundry furnishes this block; but in order to produce it, the foundry must be supplied with a pattern. The pattern shop is responsible for the production of the pattern.

The first thing to do in making a pattern for this, is to make a drawing of the pattern. As you have already learned, it will be somewhat different from the Machine Shop drawing. Begin by laying down the center lines, and then, make a full size copy of the Machine Shop drawing. (Side view is sufficient.) If you use a shrinkage rule the *shrinkage* will be taken care of. Notice that the drawing calls for C. I.; therefore you must select the cast iron, or 1/8″ per foot shrink rule. Next examine the drawing and pick out the "f's." The surface which the "f" crosses must be finished or filed off in the machine shop. On these surfaces we must add 1/8″. This constitutes

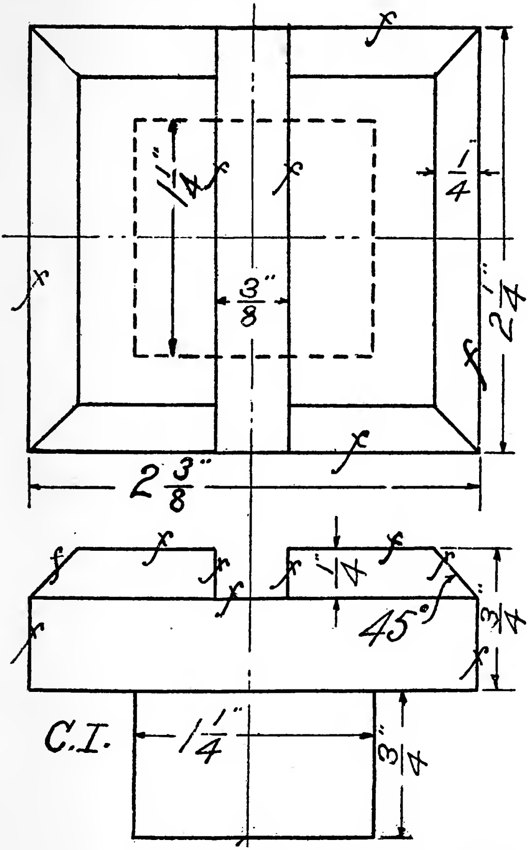


Fig. 30. Machine Shop Exercise in Chipping and Filing

the allowance for *finish.* Therefore draw lines parallel to these surfaces and 1/8″ from them. It will be noticed that, when 1/8″ is added on each

side of the $3/8''$ wide slot, only $1/8''$ space is left. No strip of sand $1/8''$ wide would stand the strain when the cope is lifted off. It would break off; therefore, the pattern maker decides it is best not to bother with it and makes the surface flat, leaving the whole slot for the machinist to

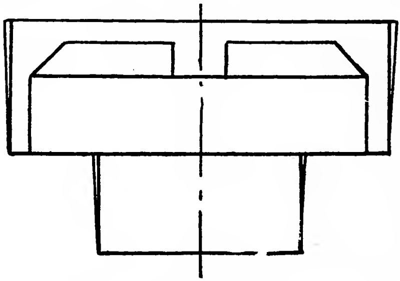


Fig. 31. Drawing of Pattern Showing Allowances

chisel out. Next consider how the pattern is to be drawn from the sand. You decide that the small block should be on the under side, the draw screw being screwed into the top of the larger block. Draw the taper on the vertical sides accordingly, remembering that this is an addition. This is the *draft.* The chamfer around the top would cause the moulder to cut a parting. Therefore, it is best to leave it out; as the machinist can easily chisel the chamfer. The pattern is now very simple. The drawing here given is not according to dimensions, and is only given as a hint as to how the pattern will look. The student must make a full size drawing according to directions above.

Now, by simply measuring your drawing, you can avoid further calculation.

Next consider the quickest way to build up the pattern. In this case, you would nail and glue the two blocks together. Now get out the two blocks, using the operations numbered one to seven of Ex. No. 1. Instead of making the face edge square with the face side, we slant it slightly for draft, then fixing the bevel at this slant, we mark off the ends with the same draft. Do this on all patterns.

Now find the center of the smaller side of the large block and, with a pair of *sharp* dividers, strike a circle at this center. The diameter of this circle is to be the width across the large side of the small block. Circumscribe a square about this circle, as in illustration. (Fig. 32.) This

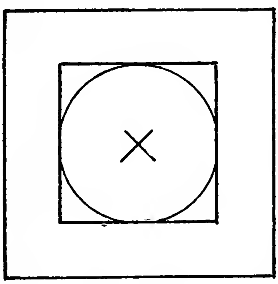


Fig. 32

will locate the small block exactly in the center of the large block. Now put a spot of glue on the small block and place it on the square and

drive two $1\frac{1}{4}''$ nails through the large block into the smaller one. The pattern is now ready to be sand papered and shellaced. When sand papering, be careful not to round off surfaces and corners.

Shellac Shellac is a varnish made from shellac gum dissolved in alcohol. Several coats of it (three or four) are applied to every pattern, with a varnish brush, and cause a smooth glossy finish.

The purpose of the shellac is *not* to make the pattern beautiful; but to cause a smooth surface which will draw easily from the sand and to make a moisture proof covering to help prevent the wood from absorbing moisture and becoming distorted.

Never have a shellac brush dripping full. Shellac only half of the pattern at a time. To avoid finger marks, let one half dry thoroughly, before catching hold of it to shellac the other half. Each coat must be rubbed down, after it becomes thoroughly dry. Use smooth, wornout sand paper, No. 0. Avoid the corners and do not rub so hard that you scratch off the shellac. A few light strokes will suffice.

PATTERN NUMBER TWO

Introducing the Green Sand Core

This is a pattern for a machine shop exercise in chipping, filing, and fitting. The drawing

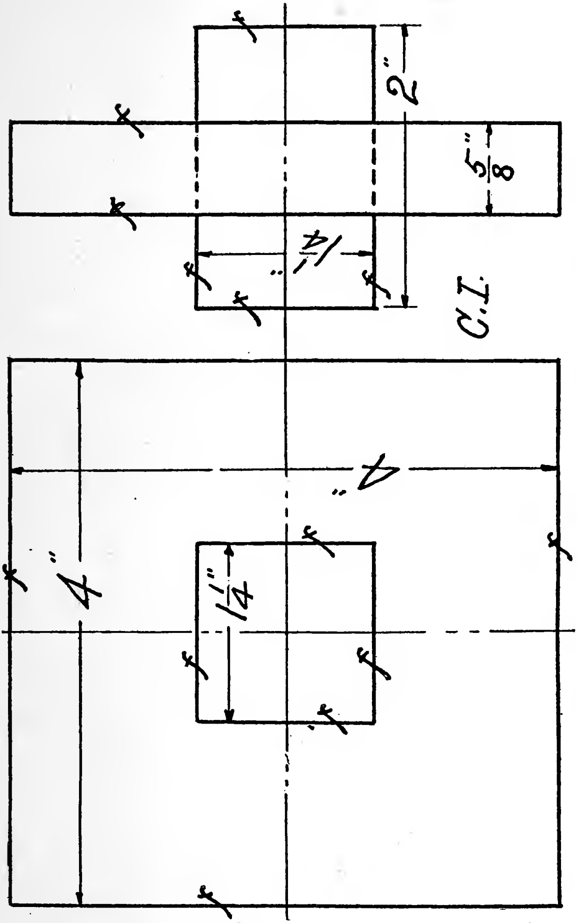


Fig. 33. Machine Shop Exercise in Chipping, Filing and Fitting

shows a square plug fitted into a square hole.

Two patterns would be necessary, one for each part; but the pattern for the plug has no value as an exercise and may be omitted. The square hole in the other piece, may be accomplished by cutting a square hole in the pattern and giving it the proper draft, so it will leave its own green sand core. Owing to the difficulty in moulding a small bar of sand, more draft than usual is allowed inside a hole. Use 1/16″ draft on each side.

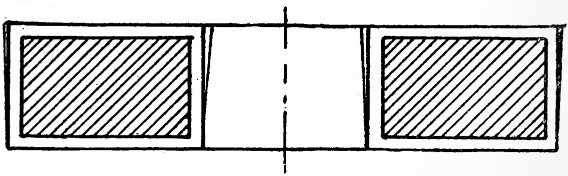


Fig. 34. Section of Pattern Showing Allowances

Instruction Card

1. Lay down drawing as before, and add allowances.
2. Plane up *blank* to the required size as usual.
3. Lay out square hole in center of *top* and *bottom* by circumscribing a square about the proper size circle, as you learned in Pattern No. 1. Make lines with a knife.
4. Bore 1″ hole within the square.
5. Saw to corners with a keyhole saw.
6. Chisel sides of hole with ½″ chisel, taking small bites and using drawing cut when possible.

7. Sand paper the hole by wrapping sand paper tightly around a sharp square-cornered stick

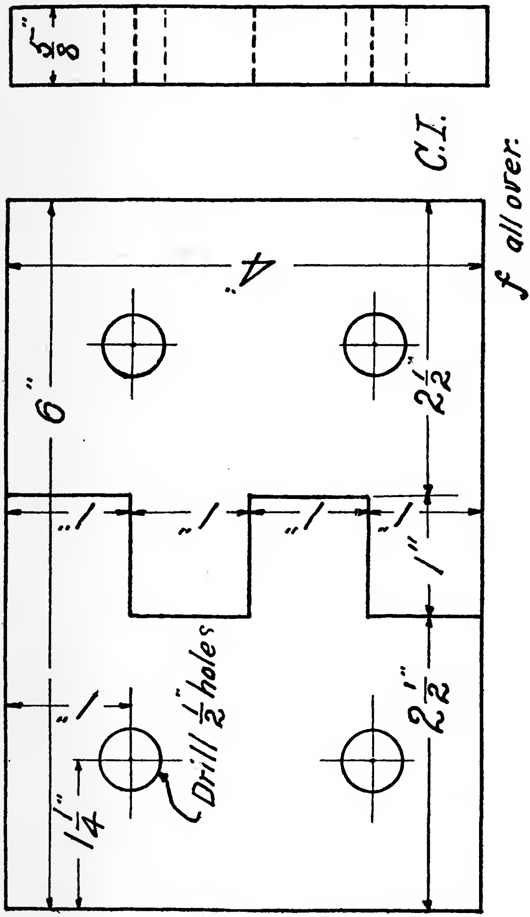


Fig. 35. M. S. Ex. in Fitting and Drilling

about ½″ square and 10″ long, using it as a file, being careful not to rock it.

8. Shellac the pattern.

Brace and Bit The 1″ auger bit used in this exercise, may be recognized by a figure "16" on the tapered shank. Place the bit in the brace and hold block in vise. Bore half way through and then turn block around and bore through from the other side to avoid breaking out chips.

PATTERN NUMBER THREE

Calling Attention to the Fact That Small Holes Under ¾″ Diameter Are Not Cored—Pattern for M. S. Ex. in Fitting and Drilling

The blue print furnished is an assembly drawing. Since both details are exactly alike, only one pattern is necessary. Simply supply the machinist with two castings from the same pattern. A new feature is the manner of marking the finish. (Note the "f all over.")

The pattern maker at once decides that the ½″ diameter hole called for is too small to core out; as the slender bar of sand would break off when the pattern is drawn; so he leaves it for the machinist to drill out.

Proceed with this pattern exactly as you did with the others. In this case, a plan and an end view of the pattern should be prepared.*

*Student should now be able to make a drawing of this pattern without a specimen drawing.

CHAPTER VII.

WOOD TURNING.

Students should become familiar with the wood turning lathe and turning tools, before they attempt to make a pattern on the lathe. A few simple exercises on the lathe will give sufficient knowledge, for this course. The lathe is a simple machine and easy to operate. A demonstration by the teacher is sufficient to familiarize the student with the names and functions of the various parts. The real difficulty to the beginner, is in handling the turning tools.

Wood Turning Exercise No. 1

Cylinder Students should first turn a plain cylinder, like that in the accompanying drawing (Fig. 36).

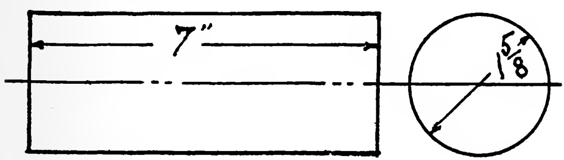


Fig. 36. Plain Cylinder

Select a piece of poplar, gum, or pine wood about 2" × 2" × 8": mark the centers of the ends

and drive the spur center into one end. Slip the spur center into the spindle in the head stock; bring the tail stock up, so that the cone center touches the center of the other end; fasten the tail stock; and force the cone center into the piece, by revolving the hand wheel. Loosen the cone center slightly and oil it to keep the pieces from screeching when it revolves. Move the rest up close to the job and fasten it. Revolve the job by hand to be sure that it clears the rest, before turning on the power.

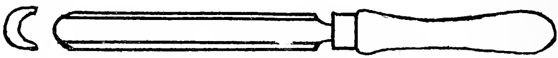


Fig. 37. Roughing Gouge

Grasp the handle of the roughing gouge (¾" or larger) firmly in the right hand and with the fingers of the left hand press the rounded back of the tool upon the rest, allowing the hand itself to bear firmly against the rest. Feed slowly in until the tool begins to cut, and then move it slowly along to the right, until the end of the piece is reached. If cutting from left to right, roll the tool slightly to the right, so that the shaving will come off between the center of the point of the tool and its right hand edge. This gives a smooth cut. Otherwise you get a scraping effect which causes a rough surface. One can cut equally well both going and coming, providing the angle of the tool is changed with the change in direction.

Take cut after cut until the piece is perfectly round and then lay aside the gouge and take the turning chisel (¾″ or larger).

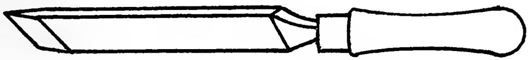


Fig. 38. Turning Chisel

Lay the chisel flat upon the rest and the job and begin to raise the handle cautiously, until it begins to cut, at the point indicated in Fig. 39.

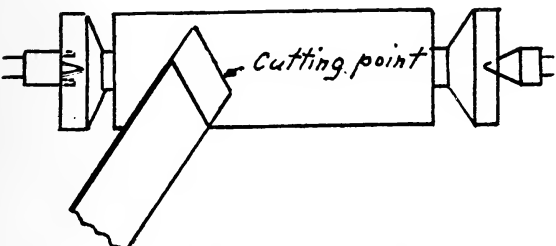


Fig. 39. Cutting With Turning Chisel

Fig. 40 also gives an idea of the position of the tool; though this cut shows the tool when the handle is raised too much. The under bevel must be kept in sliding contact with the cylinder, or the tool will dig in. The point must also be kept clear, as indicated in Fig. 40, or the tool will dig in and ruin the job.

Take a fine shaving off the full length, starting near the left hand end and moving toward the

right, until the end of the piece is reached; then reverse the tool and, returning to the starting point, cut toward the left. Do not try to start at

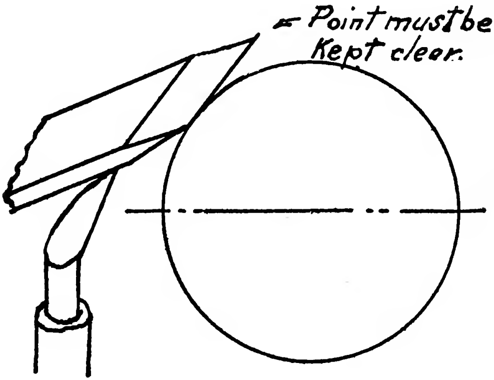


Fig. 40

the end. The bevel will have nothing to slide on and the cutting edge will dig in. Stop the lathe frequently to test with a pair of outside calipers, until the cylinder is of the correct diameter;

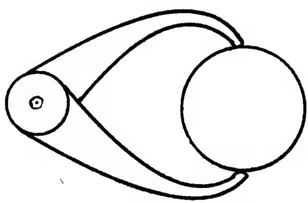


Fig. 41. Outside Calipers

then smooth the ends, holding the chisel as shown in Fig. 45. Do not sandpaper or shellac the turning exercises. The surface will be very smooth if you have followed directions and used SHARP TOOLS.

Sharpening Lathe Tools The student should learn to sharpen all lathe tools, whether chisels or gouges, with a coarse slip stone. Grasp the blade of the tool in the left hand, allowing the handle to pass under left arm. Hold the slip stone in the right hand, the thumb touching one end and the fingers the other. The hand is, in this way, shielded by the stone and there is little danger of the tool slipping off and cutting the hand. Rub the slip stone over the tool, giving the wrist free movement, and endeavor to maintain the bevel ground on the tool. Do not snub it off.

Wood Turning Exercise No. 2

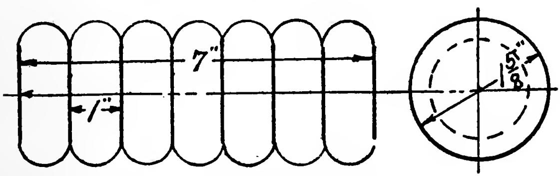


Fig. 42. Beads

Beads First prepare a plain cylinder, similar to the one described in Ex. 1; then lay off pencil line around the piece, ½" apart. Be-

ginning with the second line, make a cut with the point of the chisel at each alternate mark. Using the first mark as a center for your bead, and with the turning chisel in position for cutting, begin to roll the cutting edge deeper into the wood, swinging the handle up at the same time. In this way, a smooth round half bead can be formed. Reverse the tool and repeat the operation, for the adjoining half of the next bead, and continue, until all are nicely rounded and of an even depth.

For very small beads the point of a small chisel may be used instead of the heel, as stated above.

Wood Turning Exercise No. 3

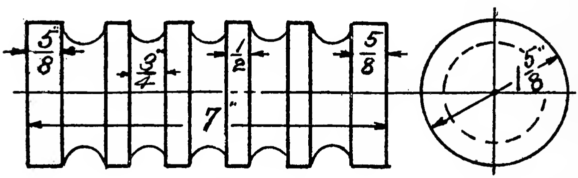


Fig. 43. Coves

Coves Make a cylinder, as before, and lay off the spaces for the coves. Make a cut at each line with the point of the chisel. Coves are turned out with a gouge. Use a ⅜" gouge for a ¾" cove. To start the cut, rest the edge of the gouge on the tool rest, allowing the cutting edge to enter the chisel mark, at right angles to the axis of the job, and, as you press the tool deeper, gradually roll it, at the same time lowering the

handle. This will raise the cutting edge and present the proper cutting angle to the wood. Next reverse the tool and take a cut from the opposite side of the cove, repeating these operations until the cove is semi-circular in form. If the tool is sharpened frequently, very smooth surfaces will result.

Wood Turning in Pattern Making

The methods given above are distinctly wood-turner's methods. Very few pattern makers can use the turning chisel and gouge in this manner.

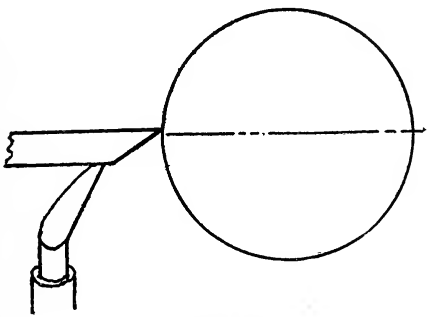


Fig. 44

The pattern maker uses scraping tools almost entirely. (Fig. 44 illustrates the scraping tool in use.) The reason for this is that the scraping tool is much easier to control than the cutting tool. The pattern maker must be very careful to get the exact dimensions and cannot afford to take

the risk involved in using the cutting tools. His work is frequently of large diameter. For this kind of work the regular turning chisel is unsuited. He uses the roughing gouge in the usual manner. He finishes with a *square point* chisel which is similar to a paring chisel except that it is longer and stronger. To turn out coves he uses a *round point* tool.

It is a great advantage, however, to be able to use the turning chisel and gouge; for more slender work can be done with them than with the scraping tools. Moreover, the latter cause considerable chatter. The turning tools should therefore be used when turning patterns of small diameter.

CHAPTER VIII

TURNED PATTERNS

Bushing The Bushing (Fig. 13) is turned between centers. This is to be made of bronze; therefore select the 3/16″ shrink rule. Proceed as in turning the cylinder. In order to turn the steps forming the flange and the core print, push the tool along in the ordinary manner, until it is very near the mark; then begin to swing the handle around, until the tool is at right angles to the axis of the job. The heel will then fit closely into the corner. (Fig. 45.)

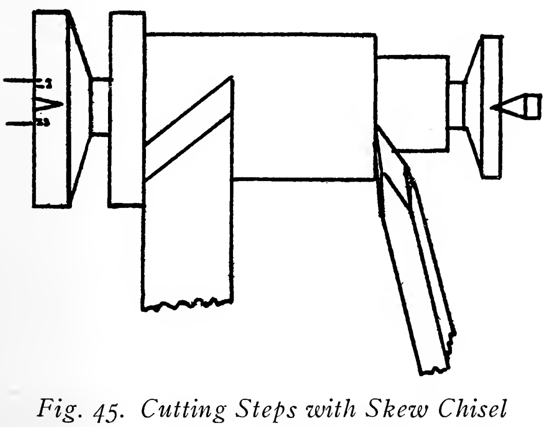


Fig. 45. Cutting Steps with Skew Chisel

The pattern and core print must be tapered very slightly to the right for draft. The cone print must be turned separately.

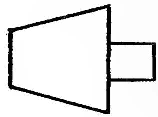


Fig. 46.
Cone Print

Its length should be about 7/8" and the diameter, at the small end, about one-half of the diameter at the large end. The pin may be about 1/2" diameter.

After the pattern has been turned to size and sanded, a coat of shellac should be applied and the pattern removed from the lathe. The ends should then be sawed off with a back saw, while the piece is held in the bench hook. Leave enough of the end on so that it can be smoothed off with a chisel. Find the center of the cope end with a center square and bore a 1/2" hole, to receive the cone print pin.

Give the whole pattern several more coats of shellac, rubbing it smooth after each coat is thoroughly dry, and finally apply black shellac to the core prints.

The bushing is *moulded on end* because it is short, compared with its diameter; but when a pattern is several times greater in length than in diameter, it must be *parted* for convenience in moulding; since such a pattern would be moulded horizontally to avoid a deep flask.*

* For the purpose of this exercise the core box may be omitted.

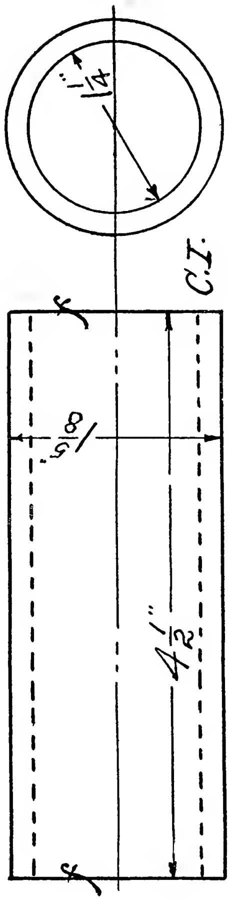


Fig. 47. Hollow Cylinder

To Shellac on the Lathe

Scrape most of the shellac off the brush on the edge of the container, and rub the shellac well into the wood. Do not have streams of shellac dripping off. Do not put the lathe in motion until the shellacing is completed. Then start the lathe to cause the shellac to dry quickly. With the lathe in motion rub the wood lightly with worn-out sand paper. When smooth remove it from the lathe. Shellacing should be finished at the bench.

A Parted Pattern

Hollow Cylinder A pattern for the hollow cylinder (Fig. 47) would necessarily be a parted pattern. The hole through the cylinder would be accomplished by using a horizontal core; therefore core prints must be provided on the ends of the pattern.

To make such a pattern proceed as follows: Get out two rough blocks, as shown in the illustration (Fig. 48). Plane off one side of each and fit them together. Make a perfect fit. The two blocks should be as long as the cylinder is to be, plus finish, plus the core prints on each end, (for patterns such as shown, prints should be about 1¼" long), plus 1½" at each end for screws, plus ½" at each end for cutting off and, when fitted together should form a parallelopiped large enough, so that a cylinder of the desired size can be turned out of it. Next calculate how far on each side of

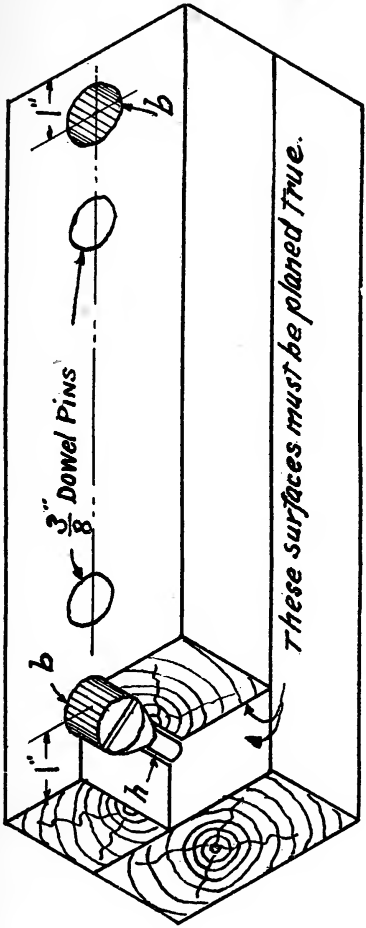


Fig. 48. Preparing Stock for Turning a Parted Pattern

the center (lengthwise) the core prints will be, and drill dowel pin holes, as shown (Fig. 49)

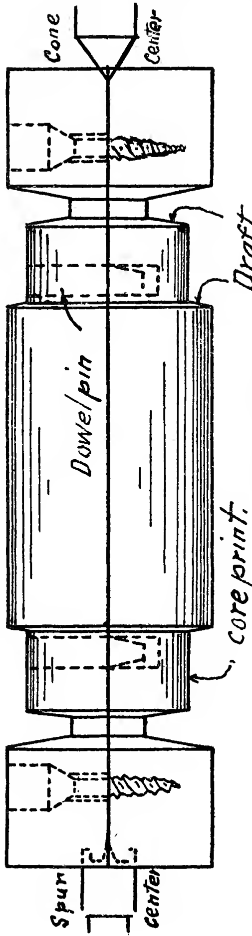


Fig. 49. A Parted Pattern

through the top piece and ½″ into the bottom piece. Taper the ends of two dowel sticks and drive them in so that the taper just comes through the top piece. Bore screw holes (b Fig. 48) a little larger than the head of the screw you intend to use. You want the head to sink below the surface about ½″ so that your tools don't strike it when turning. This is called *counter boring.*

Drill holes slightly larger than the smooth shank of the screw, as shown at h (Fig. 48). Drill no screw hole into the second block. Screw the blocks tightly together.* Punch the centers in the ends, being careful to get them exact. The center must be on the parting. Drive in the spur center. Hold the piece in the vise for this operation, so that the point on the spur center does not force the blocks apart. Now turn the pattern up on the lathe, in the usual manner, until you have reached a point, as illustrated by Fig. 49. Then sandpaper and shellac the job *once,* and remove it from the lathe and with a bench hook and back saw, saw off the ends, take out screws, and return them to their proper box. Do not saw too near the core print, as you must now take a sharp chisel and chisel the ends smooth, being careful not to chisel off the draft which you should have turned on, as shown at *draft,* (Fig. 49). Now finish the shellacing, painting the core print black and also the outline of the core on the parting of the drag half of the pattern.

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* Corrugated steel fasteners could be used; but screwing blocks together is a more valuable exercise.

The Core Box

The cylindrical hole through the casting is formed by a horizontal core. The core must be moulded in a core box, which the pattern maker must furnish. To make it, fit and pin two blocks together. For this job, the blocks should each be roughly 8″ × 4″ × 1¼″. The pin holes should be bored through one block into the other and taper ended dowel pins fastened into one of the blocks, as was done in the pattern. When the blocks are pinned together, dress off one edge square with the joints and use this as a face edge for squaring the ends, which should next be dressed off. The length of the core box is always made a little less than the over-all length of the pattern, so that the moulder will have no difficulty in setting the core into the mould.

Gage center lines on the joints and ends of the blocks, using the face edge as a guide. (See note, Fig. 50). With sharp dividers and using as cen-

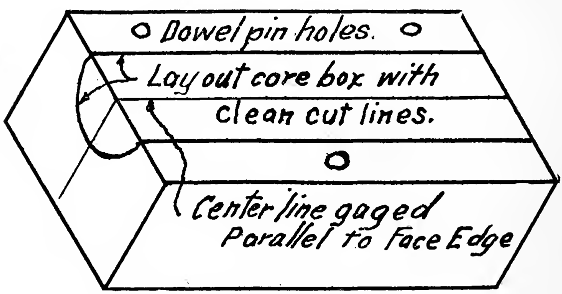

Fig. 50. Layout of Core Box

ters the intersections of the center lines with the joints, strike clean cut circles on the ends. Connect the circles with clean cut lines. All the wood

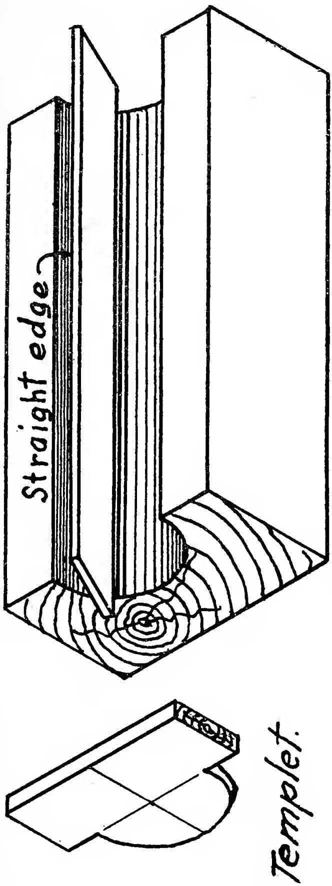

Fig. 51. Illustrating Use of Straight Edge

within the circle must now be removed. Run several saw cuts from the joint to the circle and gouge out the wood with an *inside ground gouge* of suitable radius. To insure gouging the same diameter hole, all the way through, you must make tests with a *straight edge,* as shown (Fig. 51). When all the lumps are removed the straight edge will ride on the end circles. A templet, as shown, can also be used.

CHAPTER IX

GOUGE AND TEMPLET WORK

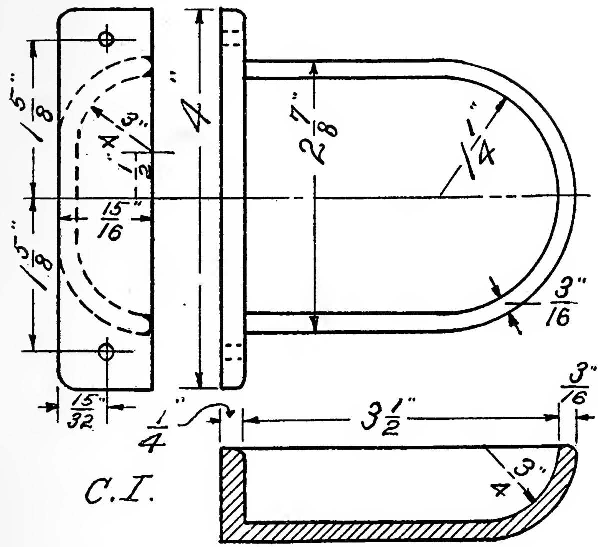

Fig. 52. Drip Cup

The Templet The most convenient way to test the depth and shape of the bottom of the drip cup, is to employ a templet. A templet is usually made of wood, about ⅛″ thick, cut to desired shape and used to test irregular surfaces.

DRIP CUP

Instruction Card

1. Plane a piece of wood to the thickness of the drip cup, but longer and wider.
2. Plane off one end, giving it some draft.
3. Lay off the outline of the cup on the face and ends. (Fig. 53.)

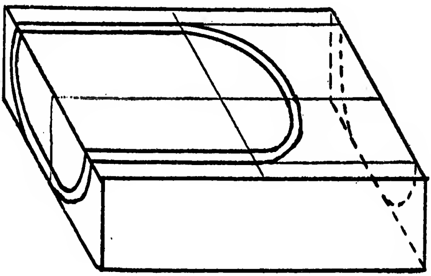

Fig. 53. Layout of Drip Cup

4. Make a templet for testing the inside.

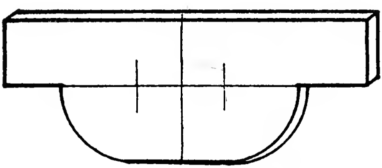

Fig. 54. Templet for Inside

5. Gouge out the inside. Use an inside ground paring gouge of suitable radius, along the straight lines, and an outside ground or a

spoon gouge, at the curved end. Clean out all lumps, until the templet can be slid along without riding on a lump, and cut deeply enough, so that the ears of the templet ride on the edges of the cup. To test the curved end, revolve the templet on the center of the curve.

6. Sandpaper the inside perfectly smooth.
7. Round off the bottom by planing down to the curves drawn on the ends. (Fig. 55.)

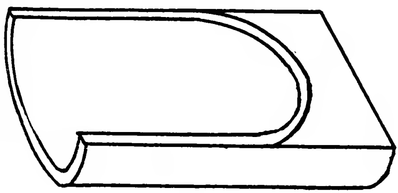

Fig. 55.

8. Make a templet for rounding off the end.
9. Saw off the end to the curved line and work it to shape with a chisel or spoke shave, testing it frequently with the templet. To

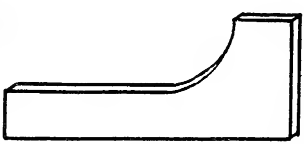

Fig. 56. Templet for Outside

keep the vise from mashing the job during this operation, shape a block to fit the inside

in order to get the pressure on the bottom instead of on the edges.

10. Make the strip which fits across the other end and nail and glue it fast. See that the draft is correct.

In moulding this cup, the hollow is formed by a green sand core which *hangs in the cope* when the cope is lifted off.

Built Up Work, Fillets, and Tail Prints

Rail Stop Up to this point, our patterns were of such a nature that they were easily cut from one piece. In most cases, however, it is more economical to build the patterns of several pieces.

To make the rail stop, get out two pieces 5/8″ thick and the specified shape for the web, and pin them together (Parted Pattern). Then get out the pieces that form the base and the curved part, and glue and nail them fast on each side of the web.

Fillets Examine any rough casting and you will find few sharp corners. Whenever possible corners are rounded. The reason for this is that, when iron cools, the crystals arrange themselves at right angles to the surface and, if a corner is left square, they join imperfectly at the corners; so sharp corners must be avoided. To save much carving, *leather fillets* have been devised which can be glued into the sharp corner.

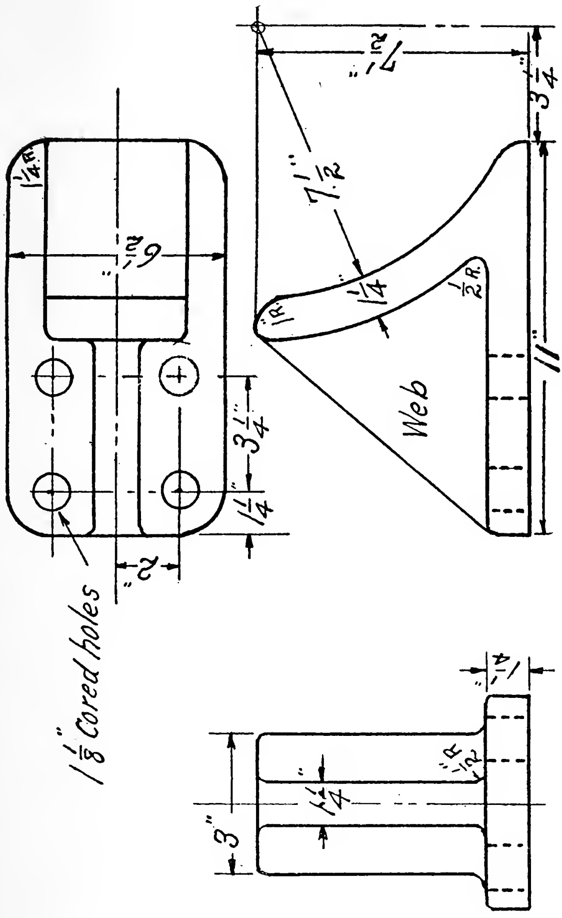

Fig. 57. Rail Stop

The leather fillet is a strip of leather of triangular cross section. To apply leather fillets, begin by cutting them to proper lengths, laying them flat upon a scrap piece of wood and applying glue. Allow the glue to dry, until it is very sticky, and then place them in the corners and rub them hard with a rounded brass rod or a fillet rubber. This presses out excess glue and gives them a round surface.

Fig. 58. Fillet Rubber

Tail Prints The holes in the base must be cored. An ordinary core print projecting from the base would not draw from the sand. To conquer this, run a tail from the print to the

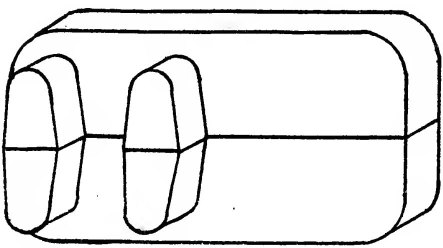

Fig. 59. Tail Prints

parting. This is called a *tail print* and must have a special box made for it.

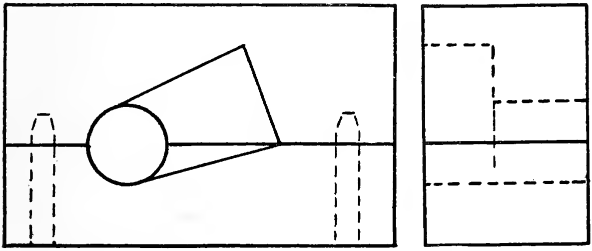

Fig. 60. Core Box for Tail Print

CHAPTER X

FACE PLATE WORK

The Chuck or Face Plate The cylinder cover (Fig. 28) is a good example of face plate work. Find a three-inch face plate. Dress off one side of a board about 7″ square and 1″ thick. Lay off a 7″ diameter circle on the board, and saw to this circle, on the band saw, if the shop is equipped with one. Screw the 3″ iron face plate fast to the true side of this disc at its center. Face the disc off true on the lathe. Use a ⅝″ round point tool for roughing, and a 1″ square point tool for finishing. Don't use a gouge on patterns turned on a face plate. Test the surface with a straight edge. Bore three ¼″ holes into the wooden disc equal distances apart and about 2¼″ from the center. This constitutes a chuck or face plate upon which we will turn a cylinder cover like Fig. 28.

Cylinder Cover Prepare a disc about 6½″ diameter and 1″ thick. Screw it fast to the chuck with 1½″ No. 14 screws, inserted in the three holes in the face plate. In screwing work to a face plate, be sure to select screws which do not go all the way through the job, and put them at such places that your tool

will not strike them when you turn deep portions of the job.

Next turn down the edge to the proper diameter, using the *spear point* tool. Test with calipers.

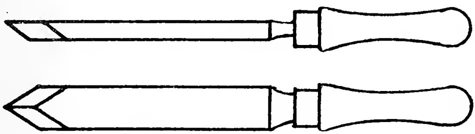

Fig. 61. Spear Point Tool

The spear point is distinctly a pattern maker's tool, with which fine smooth work can be done, if the point is kept sharp, by frequent rubbing with a slip stone. The point should always be an acute angle and the tool must be fed very slowly.

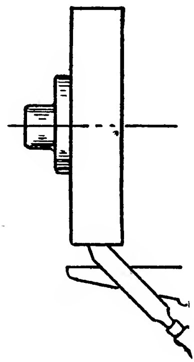

Fig. 62. Using the Spear Point

Turn the depressions in the face, with the square point, leaving enough material on the sides to turn the fillets with a ¼″ round point tool. This will be the cope side and the core forming these depressions, will hang in the cope. Give this

side a coat of thin shellac and remove it from the face plate.

Rechucking Turn a recess in the face plate about 1/8" deep and of such a diameter that you can just force your newly turned job into it. Screw it fast with the newly turned face fitting against the chuck. The pattern can now be finished with little difficulty.

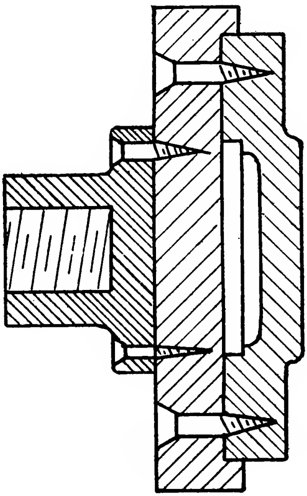

Fig. 63. Section View Showing the Rechucked Cylinder Cover

Segment Work

Segments A circular pattern, if made of a solid piece, exposes considerable porous end grain, which dries out quickly and con-

tracts, drawing the pattern into an oval shape. To overcome this, circular work is made of *segments* which gives a continuous long grain around the piece.

The segment in pattern making is most commonly the sixth part of the rim of a circle, for it happens that a pair of dividers, set to the radius of a circle, will step around the circumference of the circle in six steps. The segment is, therefore, made one-sixth of the circle, for convenience in laying out.

Segments are laid down six to a course, one

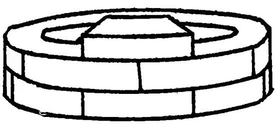

Fig. 63½. Building Up a Segment Ring

course forming a complete circle. They are made of thin wood, so that it takes several courses, glued together, to build the job up to the required height. When the second course is glued to the first, the first segment of the second course is glued and nailed so that it laps over a joint in the first course. The second segment is fitted against the first and nailed and glued, and so on, until the course is completed, when the third course is begun, its joints falling directly over the joints in the first course.

The segments are sawed out roughly on the

band saw and must be smoothed and turned to the proper dimension on the lathe, after the job is built up; therefore, the outside diameter must be made larger and the inside smaller than the required finished pattern. The best way to get the proper sizes, is to prepare the pattern drawing and set your dividers by the drawing, allowing about ¼″ for turning off.

It is too laborious a task to lay all segments out with dividers; so procure a thin piece of wood about ⅛″ thick and make a segment of it and use it to mark out the others by tracing around it. This is called a templet.

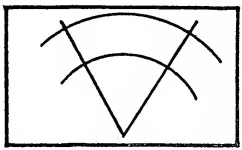

Fig. 64. Laying Out the Templet

Piston Ring

The piston ring is too slender a job for the machinist to turn out singly and, since piston rings are usually wanted in quantities, the pattern is made, so that several rings can be cut from the casting.

If we turn out a hollow cylinder of the right diameter and 3″ high the machinist can turn several rings from it. As was mentioned in Chapter III, the pattern maker endeavors to assist the

machinist in many ways. In this case, we can supply lugs or a flange, at the bottom of the ring, so that the machinist has no difficulty in fastening

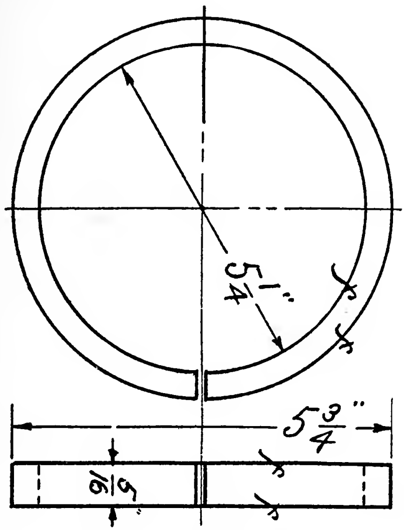

Fig. 65. Piston Ring

it to his face plate when he turns it. Without such provisions, he is likely to spring it out of shape. Taking these things into consideration, our pattern will look like Fig. 66.

Prepare a wooden face plate or chuck, such as was used for the cylinder cover. While it is rotating on the lathe, hold a pencil against it, 3¾" from the center. This will trace a circle 7½" in diameter, on the true face of the plate. Take

it to your bench and place it in the vise, face up. Rip strips ½″ thick off the edge of 2″ board, or a board of any thickness or width, and with a templet of 7½″ outside diameter and 4½″ inside

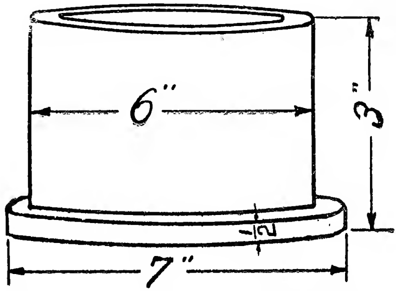

Fig. 66. Pattern for Piston Rings

diameter, trace segments on the ½″ strips, after dressing off one side. One of two methods of laying out segments may be employed. (Fig. 67.)

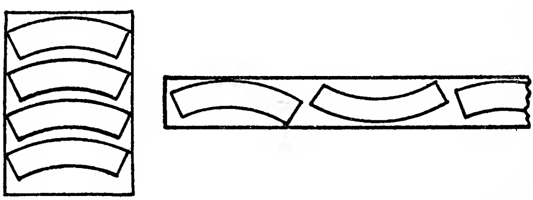

Fig. 67. Two Methods of Economically Laying Out Segments

Saw the segments right to the line, as neatly as possible. On the ends, a very small amount may

be allowed for trimming. If many segments are needed, time can be saved by nailing several boards together. Two sizes of segments are required, one for the flange and one for the body of the ring.

Take a flange segment and trim off its ends, either on a trimmer or on a shoot board; fit it to the pencil line on the face plate and nail it in place with 1¼″ brads. Do not glue it fast, or it could not be removed when finished.

Now trim off the end of another segment. If it forms a good joint with the first one and, at the same time, coincides with the pencil line, nail it in place. If not, then trim more off the end and try it again, etc. When the first course is completed start the second course (smaller segments), lapping the joints as explained above. Nail and *glue* this course to the first. By this time, the course may have become uneven, owing to possible differences in thickness of segments, and it may be necessary to go to the lathe and true off the face of the course. Do this with as few cuts as possible and do it very carefully; as the glue is not dry and, if your tool catches, the segments will be ripped off. After facing off the segments, lay another course on and face it off, etc., until you have reached the proper height. When the glue is hard (usually it should set over night), turn the outside to the proper dimensions with the spear point tool, testing it with the outside calipers.

Now swing the rest around, so that one arm will pass inside the pattern, and cautiously and slowly turn the inside smooth. The inside diameters must be tested with a pair of inside calipers.

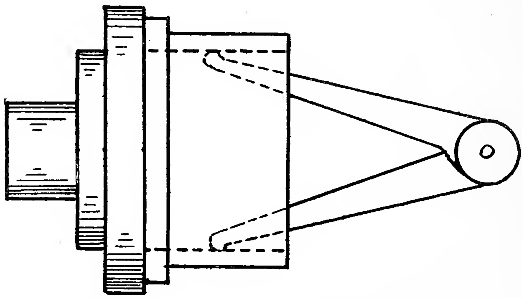

Fig. 68. Using the Inside Calipers

After one coat of shellac is dry and sanded, take the job to the vise and with a chisel, carefully pry the job from the face plate. The nails that are protruding from the bottom, can be pulled out with carpenter's pincers. The heads can be drawn through the bottom course. Fill with putty the nail holes and any defects, caused by wood breaking out at the joints on the inside. Finish the shellacing.

Lead Ladle

A pattern for a lead ladle is a good example of segment work. In this case nearly every course is made of segments of different size.

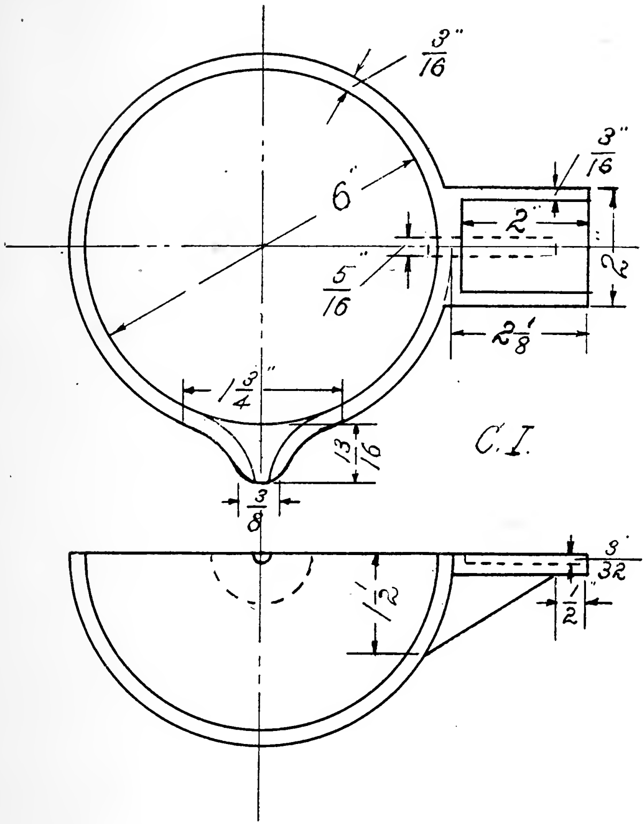

Fig. 69. Lead Ladle

Prepare a face plate as before, larger than the diameter of the ladle, in order to have room for rechucking. The bottom of the bowl is made of a solid block about ¾" thick. We cannot put any nails into this job because it is so thin that we could not avoid striking them when turning. To fasten the bottom block to the face plate, plane one surface true, then spread a thin coat of glue upon it and upon the face plate. Spread a sheet of newspaper upon the face plate, place the glued

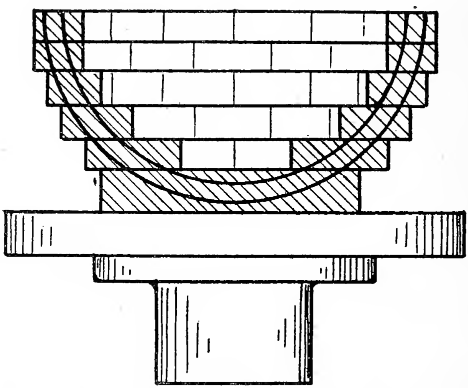

Fig. 70. Arrangement of Segments for Lead Ladle

side of the block on this and clamp. Let it stay in the clamp over night. Next morning, true off the block on the lathe and lay the segments which have been sawed of different sizes, as shown in Fig. 70. Make templets for the inside and outside of the bowl similar to those made for the drip

cup, and when the glue is dry, turn out the inside of the cup to fit the templet, using a round-nosed tool. Turn as much of the outside as can be conveniently reached. Set the calipers to the thickness of the bowl and test this portion. Give it one coat of shellac and sand paper. Now with a chisel, pry under the bottom block and the pattern will readily split off, half of the paper sticking to each piece. Now rechuck the pattern, turn the outside to fit its templet, and remove it from the lathe.

To make the handle, take a block of wood large enough for the purpose and gouge one end concave, until it fits the outside of the cup snugly; then carve the handle from this block. The spout is fitted in the same manner. The spout must be set in about 1/16", to avoid a feather edge when shaping it. Glue the whole block in and carve the spout out, after the glue is dry.

It would be a good plan to set the handle in, though it is much easier to run small screws (No. 5) through the cup into the handle.

In fitting blocks to a convex surface, chalk the surface, then rub the partly gouged block over the chalk. All lumps will be marked and may be cut down. Repeat this operation until there is a perfect bearing.

Locomotive Bell

Some students might prefer to make a locomotive bell instead of the lead ladle. The experience

gained is about the same but the bell is more attractive. Study the directions for making the lead ladle carefully, and apply them to the bell. The paper method of fastening the pattern to the

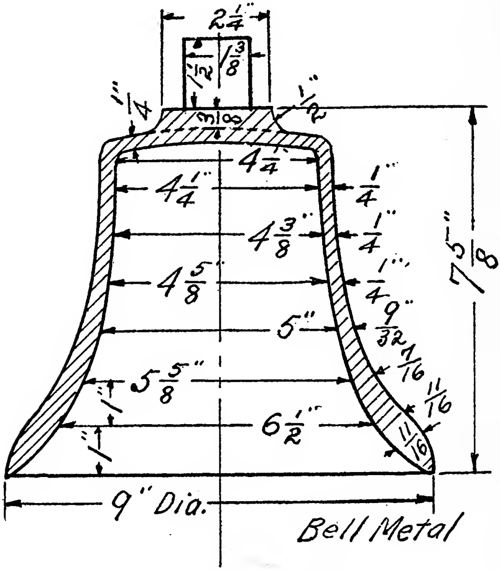

Fig. 71. Bell

face plate is probably not safe for the bell. Make the bottom block thick enough so that you can fasten it with screws. Use your layout to find the length of screw necessary. Don't have them so long that you will strike them, when turning the inside.

The spindle on top of the bell, should be turned between centers and provided with a pin, which should fit in a hole turned in the bell.

For detailed information on making a pattern for a $12\frac{1}{2}''$ diameter bell consult the I. C. S. Reference Book on Pattern Making.

CHAPTER XI

WHEELS

Hand Wheel Turn the pattern for the hand wheel from a plain board. Turn a solid web between the hub and the rim. Use a templet to get the rim circular. Rechuck it, to turn both sides alike. After you have finished turning, lay out the arms with clean cut lines. Bore a half inch hole in the spaces between the arms, insert a coping saw, and saw to the lines. Shape the arms with a pocket knife and sand paper them.

Wheels are not usually parted. The moulder cuts the parting and the impression of the upper half is lifted off in the cope.

Gear Blank

Arms In order to avoid the weak cross grain in the arms of a straight arm wheel, the set of arms or spider, as it is frequently called, is made of three pieces of wood joined together at the center.

To make a set of arms for this wheel, dress up three pieces $\frac{7}{8}'' \times 1\frac{7}{8}'' \times 10\frac{1}{4}''$. Gage center lines upon them, lay two of them out like drawing (Fig. 74), and cut out the gains thus outlined.

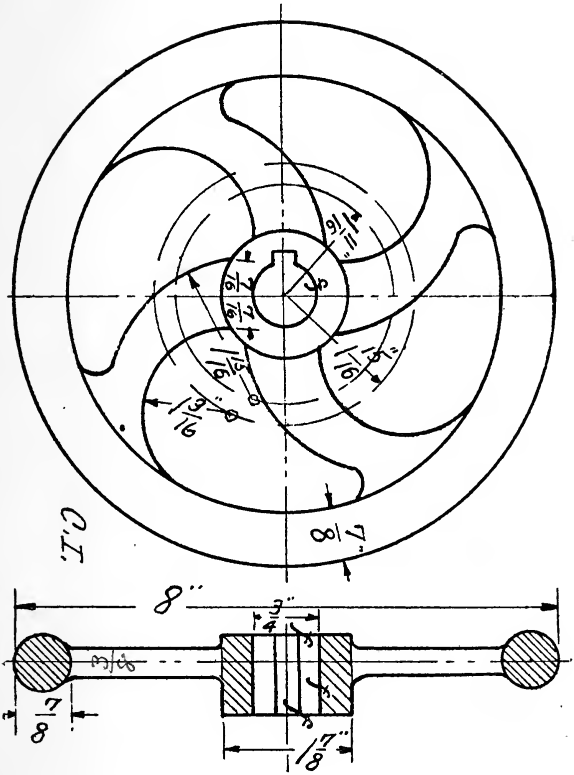

Fig. 72. Hand Wheel

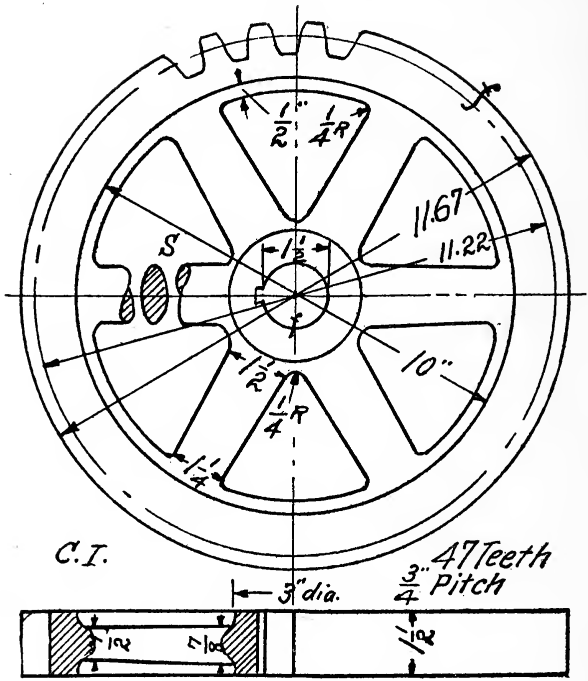

Fig. 73. Gear Blank

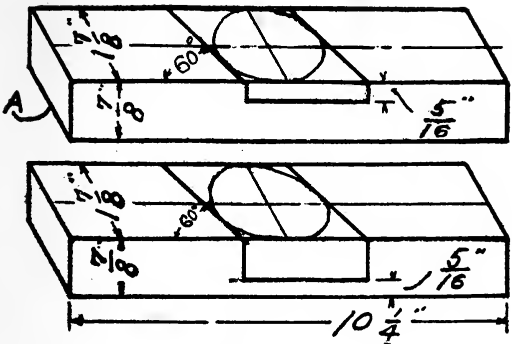

Fig. 74

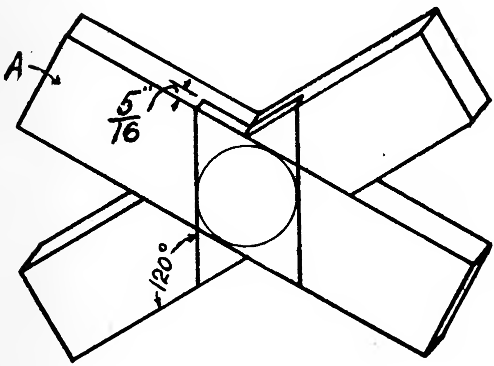

Fig. 75

Fit the pieces together. Do not force them or they will spring out of shape.

Lay out the pair, as shown in Fig. 75, and cut out the gain thus outlined. Slip the third piece into the gain and make knife lines, where it

emerges. Complete the lay out of this piece and cut out the material within the lines as shown in Fig 76. Fit the three together without forcing and glue them.

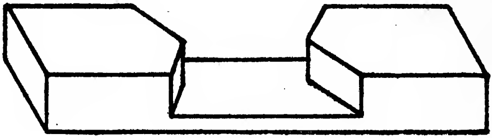

Fig. 76

The drawing for the wheel shows the arms tapered from ⅞″ thick at the hub, to ½″ thick at the rim. Perform that operation. Lay out the arms and saw to the lines. (Fig. 77.)

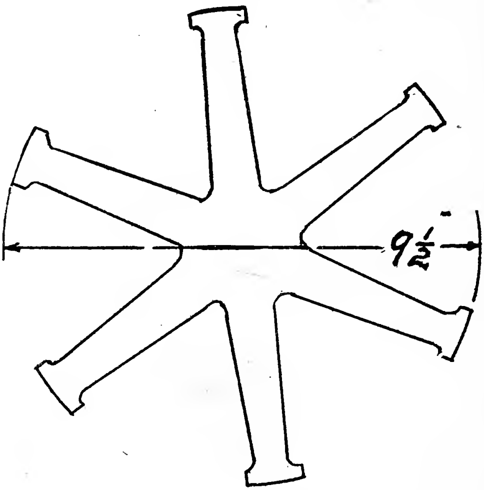

Fig. 77. Arms

Gear Wheel In these days of improved machinery, the pattern maker is seldom called upon to build a gear wheel. Instead, for small wheels, a gear blank is made and the teeth cut out of the metal by gear cutting machines. To build a blank for the wheel shown in this exercise, allow for finish on the outside or addendum circle, and build the heavy rim including the web,

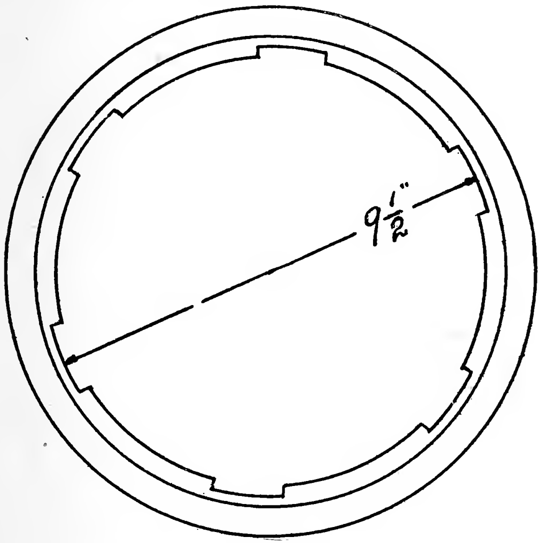

Fig. 78

of segments. Be careful not to run the lathe at too high a speed. Saw out spaces in the web in which to fit the ends of the arms. (Fig. 78.) Glue the arms in place. Run a dowel pin, or nails,

through the rim, into the ends of the arms. Shape the arms to the elliptical cross section, as shown at S. Fig. 73, with a pocket knife, small spoke shave, and sand paper.

Turn up the bosses for the hub separately, and nail and glue them in place. The hole in the hub should be cored. Place a print on one side only. This being a very short core, there is no necessity for having a cope print. A short core is not likely to be moved out of its vertical position. Draw a black circle on the cope side, to indicate to the moulder that the core comes all the way through. No core box need be made for this. Every foundry has standard core boxes or a core machine. The moulder takes a standard 1¼″ core and cuts it off to the correct length for use in this wheel.

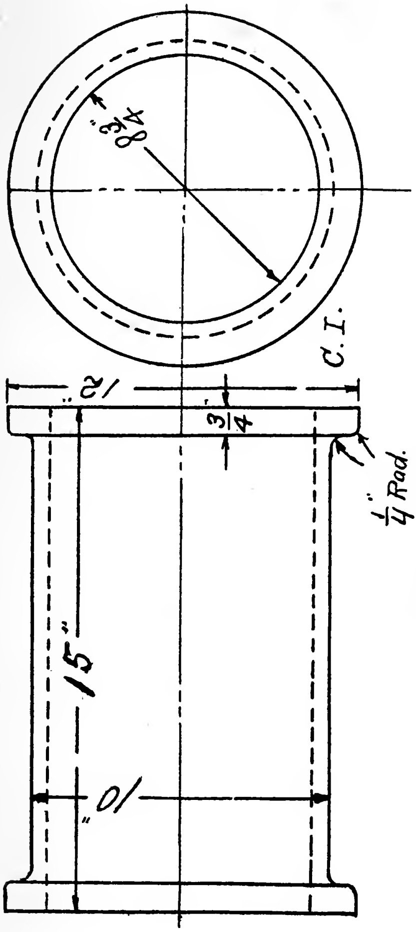

Fig. 79. Flange Pipe

CHAPTER XII

STAVES AND STRIPS

Flange Pipe In order to prevent the distortion caused by the shrinkage of wood across its grain and to save material, a cylinder over ten or twelve inches in diameter is *staved*. (Fig. 22.)

To determine the size and shape of the staves make a layout of the cross section of the pipe (Fig. 80). Decide how thick the staves should

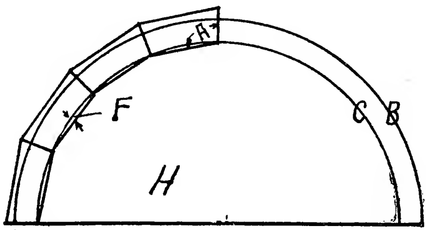

Fig. 80. Layout to Determine the Shape of the Staves

be, to produce the proper strength. In this case, they should be made of 1″ lumber. Allowing ⅛″ for dressing and turning and about 1/16″ for the flattening of the curve at "F" (Fig. 80), we may draw a circle "C," 13/16″ inside of the circle "B" which represents the outside of the pipe. Judge

the number of staves you should use (in this case, 16), and divide the semi-circle "C" into eight equal parts. Connect the division points by straight lines. This represents the bottom of the stave. To represent the top, draw a line parallel to it and 15/16" from it. The edges are represented by lines drawn from the center through the division points. Set the bevel to angle "A" (Fig. 80). Saw sixteen strips from a 1" board, a little wider than necessary, and 15⅛" long; dress them off to the correct thickness, and plane the edges to the correct angle. This can be tested with the bevel.

This work is very simple, if the shop is equipped with a jointer, planer, and circular saw; but it can also be done with a band saw and hand plane. To get the angle on the edges, set the circular saw, or band saw table, to the proper angle, as given by the bevel.

Next get four half heads, about 9½" in diameter, and 1" thick. Lay out circle 'C" (Fig. 80), divide it into 8 parts, and flatten the curve to receive the 8 staves. (H Fig. 80.) Draw two parallel lines perpendicular to the edge of some straight board, and 15 1/16" apart. Toe-nail a half head to coincide with each line. Nail a brace in place against each head, to keep it perpendicular to the board, and proceed to nail and glue the staves in place. (Fig. 81.)

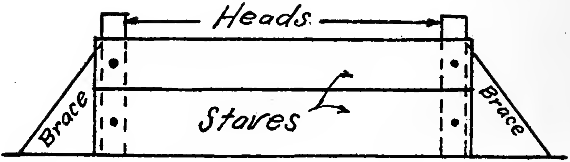

Fig. 81

This is one-half of the pattern. Proceed with the other half in the same way, and then pin the two halves together with dowel pins. To mark the centers for the dowel pin holes so that they will match in both halves, place two small brads on the joint between the halves, and pound the halves together with a stroke of a mallet. The head of the brad will mark both halves at the same point and, if this is used as a center for the auger bit, the holes can be bored to match, The pins should be placed in the heads.

The ordinary spur and cone center will not do for turning a job of this size. Iron plates (Fig. 82) are made, which can be screwed fast to the job.

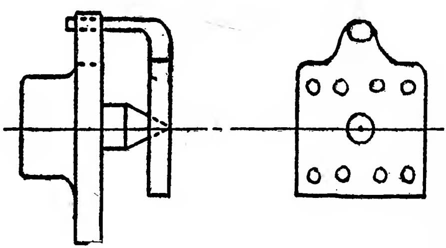

Fig. 82

Each contains conical depression into which a cone center fits and cone centers are used in the head and tail stock. The job is revolved by a dog, projecting from one of the plates and passing into a slot in a face plate. If no such center plates are at hand, the spur center can be made to do the work by making a pair of hardwood blocks, about 4″ square provided with screw holes and deep cuts to receive the spur and cone centers. (Fig. 83.) Pinch dogs should be driven into the end across the joint, to help hold the job together.

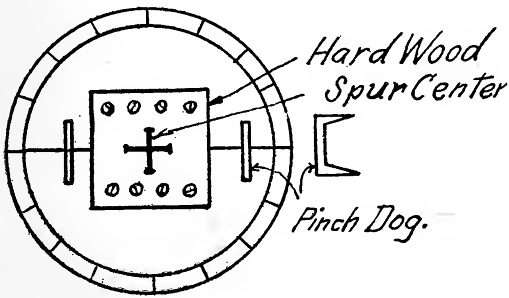

Fig. 83. Center Plate

To turn this job, use the square nosed tool and run the lathe at its slowest speed. If you forget this warning, you may have a bad wreck and probable injury; as great speed will throw the job out of the lathe. Do not attempt to caliper the job while it is in motion. Use a straight edge to test it lengthwise.

Turn recesses on the ends to receive the flange (Fig. 84). Make the flange of four segments, nail and glue them to the cylinder, and turn it to size. If your lathe will not swing twelve inches, cut down the flange to a smaller diameter.

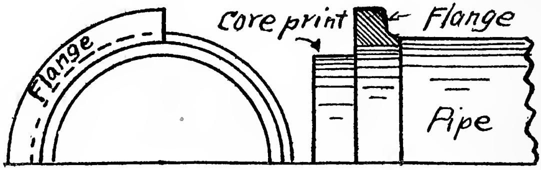

Fig. 84

The core prints can be sawed out of two-inch stuff, dressed off with a spoke shave, and nailed and glued in place; or they may be turned on a face plate.

The core box should be *stripped* up. Make heads, as shown in Fig. 85, and nail and glue

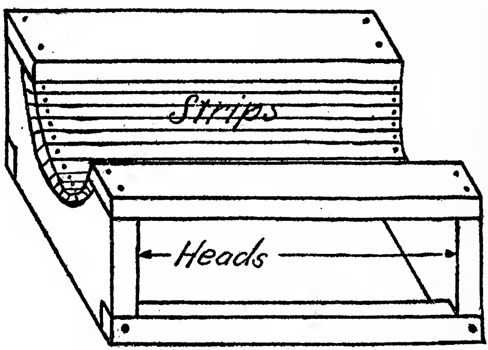

Fig. 85

⅞" strips inside. The narrower the strip the less to dress out. This box can be dressed out with a spoke shave, or round bottom plane of suitable radius. The core prints can be fastened on the end, and boards, nailed across the ends of the core print. (Fig. 86.)

This half box is all that is necessary for such a job. The core maker rams the box up twice and pastes the two half cores together, to form a whole. This can be done with any symmetrical core.

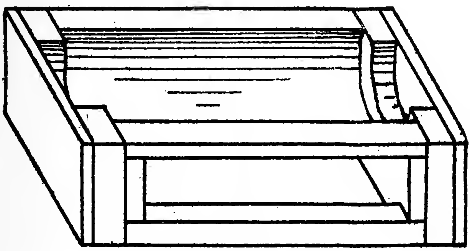

Fig. 86. Core Box

Loose Pieces

Cylinder Cover The cylinder cover, given in Fig. 87, would be impossible to mould by any method so far considered, without a troublesome core box. By resorting to *loose pieces,* the operation is simplified.

This pattern should be parted on the line "A-B." Both halves can be turned on a face plate. The round part "P" should be turned straight, and

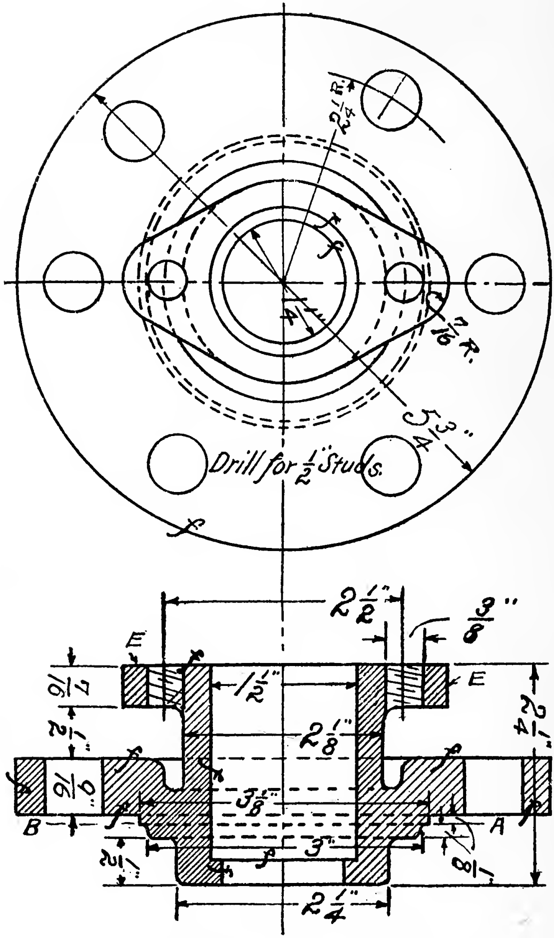

Fig. 87. Cylinder Cover

the ears "E, E," set in, as shown in Fig. 88, but not permanently fastened.

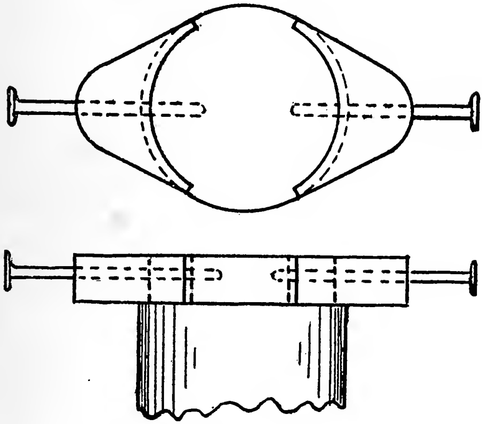

Fig. 88. Loose Pieces

They are held in place by loose dowel pins, or large nails, slipped into holes bored through the ear into the pattern.

The moulder rams up, until the loose pieces are covered with sand, when he digs into the sand and removes the pins. The loose pieces will then be held in place by the sand. When the ramming up is completed and the pattern drawn, the pieces remain in the sand. The moulder reaches down, and with a sharp point picks them out.

Pupils finishing this course before the end of

the year are prepared to build a set of patterns for a simple machine which could be designed in the drawing room. The foundry, forge and machine shops should co-operate in building the complete machine. Patterns for such machines may be substituted for the given exercises if they cover the same points.

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